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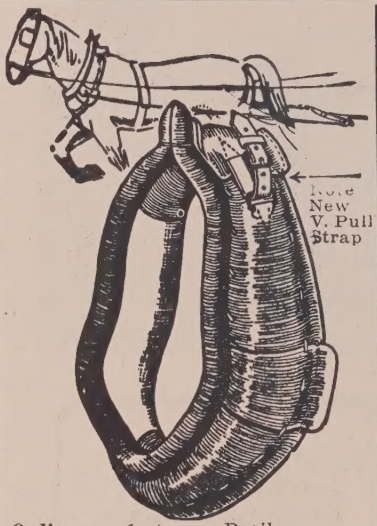

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VOL. 6, No. 1 MARCH, 1940

Nutrition and the Public Health

Of more than ordinary interest at this time are the proceedings of the conference held in London last year on the subject Nutrition and the Public Health.* The conference was called at the instance of the British Medical Association, and the interests represented comprised medicine, agriculture industry and education. Nutrition, as stated by Professor Cathcart in his opening address at the medical session, is much more subtle than the mere provision of adequate food, the other essentials being adequate sleep, fresh air, exercise and contentment of mind. In the matter of food itself, a great

* Nutrition and the Public Health, Proceedings of a National Conference on the Wider Aspects of Nutrition (150 pp.). London : British Medical Association, 1939. Price 2s. 6d.

deal is known concerning the composition of the majority of ordinary foodstuffs, although for materials like the mineral salts and the vitamins our information regarding their quantitative requirements is extremely scanty, and the widespread belief that it is possible to draw up a series of diets which will be perfect in the sense that they will meet every requirement of the body is ill-founded. But in spite of this, more practical steps are needed to guide families in the selection and preparation of the right food. Sir John Orr estimates that the average amount spent on food in Great Britain is 9s. per capita per week; that the average diet of the poorest group, comprising 4½ million people, is deficient in every necessary constituent; that the second group (9 million people) is adequately supplied with protein but is deficient in all the vitamins and minerals considered; and that the third group (9 million) is deficient in vitamins and minerals. As income increases, consumption of nourishing foods increases and disease and death rate decline. That the poor are only able to get a third as much milk as the rich is due to restricted purchasing power, and, as Sir Arthur Salter pointed out, the consequences to children's health and the economic penalty to large families become immediately apparent for milk is in itself the nearest approach we possess to a complete food. Unfortunately, this product is treated primarily as an important part of the incomes of farmers, and secondarily as the most essential of foods.

Whatever the professional, technical and medical aspects of a nutrition policy, its application necessarily involves questions of economics, administration and legislative provisions. With regard to agriculture, in spite of the big increase in both home-produced and imported supplies of health-protecting foods, there is insufficiency of them and, as advocated by Viscount Astor, Britain's agricultural policy should be to supply more of those perishable foods (butter, fruit, meat, eggs, etc.) where propinquity to market provides a natural advantage. At present, Britain produces at home all potatoes required, the liquid milk and much of the vegetables; about half the meat and fish but only 15 per cent. of the wheat and some 10 per cent. of butter. Britain produces less than 40 per cent. of the total money value of her foods, and less than 50 per cent. of the total weight. The chief cause of malnutrition in Britain is considered to be lack of purchasing power, and any agricultural policy which reduces the purchasing power by putting up the cost of living would still further render the people liable to malnourishment. Viscount Astor pointed out that the present agricultural policy involved a large expenditure of public money, most of which helped only a few farmers to grow crops not needed for the well-being of the people, and he outlined a policy calculated to make a real nutrition policy possible in that cheaper food would

be available to all and farmers themselves would be rendered secure and prosperous. In contending that the main cause of malnutrition in Great Britain was a wage system which took no account of family needs and responsibilities, Mr. L. S. Amery argued that the simplest and most effective measure to correct these ills would be the institution of a system of family allowances from the general wealth of the nation ; that the handicap imposed on family life by the flat rate wage system should be directly relieved, and in direct proportion to the extent of the handicap, by some regular contribution. Although a number of countries have instituted family allowance schemes, the only schemes in existence in Britain are those which have been initiated by certain individual firms at their own expense. The credit for originating the system of family allowances belongs to France, where it developed during the Great War.

It is of interest to note here that in Australia, where more food per head of population is produced than in any other country except the Argentine, there is a considerable mass of minor departures from normal health described generally as malnutrition. The Commonwealth Advisory Council on Nutrition, formed in 1936, stated in its final report that this malnutrition was due partly to economic factors, partly to inadequate supplies of perishable foodstuffs (in country districts), but very largely due to the result of faulty selection of diets. While Australians are, on the whole, better fed than other people, the Advisory Council found that up to 33 per cent. of the children examined were malnourished. There was an almost universal deficiency of foundation foods, such as milk, eggs, cheese, fruit and vegetables, coupled in many cases with too great a consumption of refined carbohydrate foods. Well-to-do as well as poorer households showed the same general tendency, thus indicating that misguided selection of food was an important causative factor. In Australia, as in Great Britain and elsewhere, there is a real need for an efficient educational system whereby the importance of relative food values can be grasped by the general public. It is regrettable that so much emphasis has been placed on the chemical rather than on the physiological approach in extension schemes, for, as stated by Professor V. H. Mottram at the London conference last year, the need is for propaganda, not for calories, vitamins and proteins, but for the increased consumption of the protective foods, and in this it is essential to dispense with the jargon of the dietitian.

Agricultural Education, Research and Extension in New South Wales*

By

E. Breakwell, B.A., B.Sc.,

Inspector of Secondary Schools and Supervisor of School Agriculture, Dept. of Education, Sydney, N.S.W.

In this address I desire to set out (1) the present conditions of secondary and adult agricultural education, and (2) the organisation of agricultural research and of extension, in this State. In connection with the last named I shall compare our extension work with that in the United States, and will demonstrate that although a larger amount per head is spent in New South Wales, the organisation of our extension work suffers in comparison with that in the United States, and full advantage is not taken of our potentialities, either with regard to our agricultural wealth, or with regard to the number and quality of our agricultural officers. I shall endeavour to show that on general principles the development of agricultural education has proceeded on similar lines here to those in America, but we appear to differ in the details of our organisation, and, in my opinion, are suffering as a consequence.

Historical Retrospect.

The close similarity of the development of agricultural education in this State to that in the United States is most marked, but not surprising. Here, as in America, new lands had to be developed by immigrants of British or European stock. New problems connected with the soil, plant and pests were continually arising. In the early stages, both here and in America, farmers depended for guidance in agricultural principles on local agricultural societies, the members of which organised the local and district shows. In America such organisations were known as Farmers' Institutes, and these provided most of the agricultural education prior to the passing of the Smith-Lever Act in 1914-15. No field demonstrations were conducted in that country until 1905. In this country agricultural education developed more rapidly in its early stages than it did in America. Australia was only 100 years old when the Department of Agriculture in N.S.W. was formed, whereas in America only small grants by State and Federal Governments were given to Farmers' Institutes during the first 300 years of its history. During the past 40 years agricultural education has developed in both countries on somewhat similar lines as far as general principles are concerned, although there are many dissimilar features in the details of the organisation.

* Presidential Address to N.S.W. Branch of the Institute, 9th February, 1940.

Secondary Agricultural Education.

Agricultural education was introduced into our secondary schools about 1916. The course, however, was not popular, despite the efforts of agricultural teachers to develop interest. An attempt was made some years later to revive interest by establishing a number of district rural schools. Once again, however, popular support flagged, due probably to the shortage of skilled teachers (especially graduates), the absence of facilities for practical work, and a misconception of the principles and value of agricultural education. Over a long period of years, it has been found necessary in America, as well as in Australia, to emphasise the cultural, as distinct from the vocational, value of agricultural education. For example, at the National Education Conference in the United States in 1911, Professor Crosby stated: "Agriculture is much more than a vocational subject. In one way or another it touches nearly every human interest and endeavour. In some aspects it is economic, in others it is social, æsthetic and scientific. It is a liberalising and cultural subject, and should be studied in every high school." It might be claimed that a boy with a secondary agricultural education does not, on reaching manhood, become an isolated unit in the community. He can cooperate in all movements for general progress because he appreciates the value of agricultural progress in such.

A fresh start was made in 1922 to develop secondary agricultural education. Conditions were more favourable, because agricultural science graduates and Hawkesbury Agricultural College trainees were available and the respect for agricultural scientists was also growing. Since 1928 the improvement in secondary agricultural education has been consistent, without being startling. At the end of 1928 there were 850 agricultural students and in 1934 the number was 1,097. Last year (1939) there were 2,865 students, and of this number 522 were in the third or intermediate year. This education is now carried out at 3 agricultural high schools, 9 ordinary high schools, 3 intermediate high schools, 15 district rural schools and 7 public schools. There are 37 agricultural science graduate teachers, 8 Hawkesbury Agricultural College diploma teachers, and 19 teachers who have been trained at Hurlstone and Yanco Agricultural High Schools, and at Armidale or Sydney Teachers' College.

A further advancement was made in 1934 by the establishment of a five years' course. This has been well supported, and last year there were 59 fourth and fifth year students at Hurlstone, 32 at Yanco, and 11 at other high schools. Fourteen scholarships are awarded at the end of the intermediate year to the senior courses at Hurlstone and Yanco, or to Hawkesbury Agricultural College.

Although the progress in agricultural education is encouraging, we are still far removed from an optimum development. Figures show that there are still 25 to 30 per cent. of secondary pupils residing on farms who do not take agriculture. If parents could realise that only one-fifth of the school time is

occupied with agricultural subjects, and that the pupil receives the same benefits from the other important subjects as the pupil who does not take agriculture, and if teachers and extension officers increased their knowledge of psychological and sociological problems, a good deal of parental resistance might be overcome.

University Agricultural Education.

The Sydney University School of Agriculture was established in 1910 in recognition of the need of more adequate facilities than existed at Hawkesbury Agricultural College and Sydney Technical College. It has progressed rapidly ; for example, in the thirteenth year there were 25 students, in the twenty-sixth year the enrolment grew to 48, while at the present time there are over 70 students in the Faculty. Many of the professional positions in the agricultural, and teaching positions in the educational, departments have been filled by graduates.

Extension and Research.

There are 186 officers of the Department of Agriculture in this State educating the farmer. In the United States of America there are 8,149 county extension and assistant agents. On a population basis this corresponds to 60 officers per million, whereas in this State our numbers correspond to about 70 per million. The amount spent in extension work in the United States in 1936 was nearly £18 million, which approximates to £27,000 per million of population. In proportion our State should spend £72,000, whereas last year £143,000 was spent on educational, scientific and field work. Many of our officers, however, are not engaged entirely on extension work, and in the scientific branches of the Department a large amount of time is occupied in identification and routine work. While efficiency in routine, research and extension will improve the quality of any *one* man's work, the maximum value would probably be obtained if the officers were graded into three types, viz. those engaged in identification and routine, extension officers, and research officers. A State research station should be established, and it is suggested that this should be built at Hawkesbury Agricultural College. Routine assistants are also needed. Such men need not have an intensive scientific training, but should perform similar duties to those of university laboratory attendants. They could perform laboratory tasks which require only care and accuracy in manipulation. An expenditure of £2,000 per annum would pay the salaries of four assistants in the scientific branches, one assistant to two scientists. Much more time for absolute research would then be available for these highly trained officers.

The C.S.I.R., according to its latest report, has 229 officers engaged in research work in agriculture and animal husbandry. The potential value of these researches to our agricultural wealth is undoubted. In order, however,

to obtain the greatest value from this work certain questions arise: Is there the maximum amount of collaboration with the State officers concerning the research problems, and is there any overlapping? Are suggestions for research received from State officers, and acted upon? Have all research officers sufficient practical experience to evaluate correctly and fully the results of their researches? To what extent are the investigations and discoveries applied to farming practice? Is there an earnest spirit of cooperation on the part of State officers, and a desire to assist and extend the researches of the C.S.I.R.? Does the State Government receive sufficient remuneration from the Federal Government for its collaboration, and is there an allocation of time or definite periods fixed by the State Department to enable State officers to collaborate and carry out, not only research, but extension work connected with the problems? Discussions with various scientific officers have prompted these questions.

Organisation of Extension Work.

The rapid changes that are taking place in connection with the varying demand for our primary products will probably necessitate a change in our agricultural policy in the near future. Such will be expedited if the policy of self-sufficiency in European countries is maintained. However, one cannot yet foresee the changes that will take place in international trade as the result of the war. In 1936-37 the German Secretary of State reported that if the German people could import foodstuffs from the world's markets to the same degree as at an earlier period, their consumption would increase by nearly 20 per cent.

The United States are attempting to solve the problem of economic national production through such organisations as the Agricultural Adjustment Administration and the Rural Settlement Administration, the programmes of which are carried out by the extension officers. Farm-planning is considered from the point of view of the value and possible marketing of the products obtained. There is the short-time outlook which reflects current conditions and the longer-time outlook for specific agricultural commodities and their relationship to the future general economic situation. By bringing our extension work in line with that in America, it would probably be made more effective. There it is partly financed, but not controlled, by the Federal Government. Sufficient funds to carry out the work are allocated to the various States. Since our Federal Government determines the exportation of our various primary products, surely it is their responsibility to determine the amount of extension work necessary to develop such products, and finance it accordingly. This work should be carried out by State officers trained for the purpose, and it should be a full-time job for such officers. There should be the closest cooperation, not only between the C.S.I.R. and the States, but between the various State scientific and field branches, and between the specialists and extension officers.

Farm-planning for the States as a whole, and also for the various parts of the States, should be organised by means of:

(*a*) Conferences between the Federal authorities and the State Departments, when the agricultural planning of Australia should be considered in the light of local requirements, and the exporting potentialities of various products.

(*b*) Conferences between representative specialists of the various State branches, university, private agricultural organisations and extension officers, when farm-planning for the various zonal areas of the State should be determined, bearing in mind the result of conferences outlined in (*a*).

(*c*) Conferences between country district agricultural organisations, farmers, and extension officers to determine the farm planning and procedure where the corresponding extension officers are operating, bearing in mind considerations determined upon in the conferences of (*a*) and (*b*) and also by local conditions.

Extension work carried out by private organisations should be approved by the State Department.

Training of Extension Officers.

It is now generally recognised both here and abroad that extension officers require more than practical efficiency in their work. The late Assistant Director of Extension Service in U.S.A., Dr. C. B. Smith, reported that " The time calls for still better trained extension agents, if the work is to keep pace with the farmers and their needs. It is not enough to graduate from a four years' course in agriculture. Extension agents need to be trained in economics, sociology, administration and philosophy. From five to seven years' intensive training and practical field apprenticeship would seem to be necessary to prepare extension agents for the great work now before them. We all need to recognise more fully the units of approach essential by the college teaching faculty, the research workers, and the extension service if the greatest help is to be given to the rural people."

America endeavours to have extension agents with a thorough educational training. Ninety per cent. of the county agents who expressed opinions believe in specialised training, and give psychology and subjects in education a large part in their programme. Dr. Warburton, Director of Extension Service, whom I interviewed in Washington last year, assured me that graduate teachers who transfer to extension work carry over to their job the undoubted value of their teacher training. In the training for extension agents courses are given in rural economics, rural social science and other professional studies. The Smith-Lever Act places the responsibility for the actual conduct of the work on the agricultural colleges, and provides for cooperation between the college and

the Federal Department. Quite recently it was decided that a closer relationship should be established between the staffs of the experiment station and the extension service.

Practically all our full time extension officers in N.S.W. are men who have graduated from Hawkesbury Agricultural College. Undoubtedly, they have received a good training in the growing of various crops and pastures, and can also receive there a good training in orchard management and in the control of insect and fungous pests. But they have received no special training in instructing, or in psychology and rural sociology, essential requirements if contact with the farmers is to be productive.

Hawkesbury College can and should provide these requirements with the necessary financial assistance from the Government. Only those officers who pass the necessary grade in these requirements should be admitted as extension officers. Fruit instructors and inspectors should be chosen from those who excel in orchard management and in the control of insect pests and fungous diseases.

Extension officers who will be engaged on highly specialised work should be drawn from the scientific branches, viz. those dealing with chemistry, plant pathology, entomology and bacteriology. These officers should have an intense practical training, and should prosecute special courses of study at the University or Teachers' College in psychology, rural economics and sociology before appointment.

Rural economics requires special emphasis. We do not appear to be sufficiently prepared for changes. Consider the present demand for bacon, the desirability for improvement in wheat quality, the threat of over-supply of fruit, and so forth. Consider how many farmers have been ruined by using undesirable types of machinery, and through using tractors, without the necessary warning. (See "Economic Problems in Agriculture", by A. R. Callaghan, *J. Aust. Inst. Agr. Sci.*, 5: 188–193, 1939.)

Although we can point with pride to many factors in the agricultural development of Australia, particularly the achievements of the graduate scientists, the number of farmers taking advantage of the researches and discoveries is extremely limited. Many farmers are still in a quandary as to what to grow, how much to grow, and the best way of growing it. Mr. J. L. Gillespie, of Victoria, has shown how effective individual farm-planning has become in Tasmania, and such planning should be extended to the whole of Australia. This Institute should play a prominent part in the direction of the technique of such a development.

Costs of Operation of Producer Gas Tractors in Western Australia

By
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Producer gas plants were first used on tractors in the West Australian wheat belt in 1931 at a time when disastrously low prices forced farmers to explore every possible avenue for reducing costs of production. Improved wheat prices and the unsatisfactory experiences of a number of farmers with their plants caused interest in producer gas to wane until about two years ago. Since then improvements in the gas plants on the market, war fears and falling wheat prices have combined to stimulate public interest in the possibilities of charcoal as a substitute fuel for petrol and kerosene. The outbreak of war assured the immediate future of producer gas as a fuel for internal combustion engines.

The advantages and inconveniences attached to the substitution of charcoal for kerosene and petrol are now too well known to warrant repetition, but details of the operation of several producer gas and kerosene tractors over a 12-months period are likely to be of considerable interest. Information of this nature was obtained in the course of an investigation into the costs of tractor operation in the Western Australian wheat belt, carried out at the Institute of Agriculture in the University of Western Australia. Records of the operation of 46 tractors, of which seven were producer gas powered machines, were obtained. In Table 1 the performances of these producer gas tractors have been set out, and, for comparison, the records of five kerosene operated machines have been included.

All the tractors were equipped with rubber tyres.

Several of the producer gas tractors were old machines which had been reconditioned prior to the fitting of tyres and gas producers.

The rated draw-bar horse power figures are those given in the Nebraska tractor tests for that particular model tractor on steel wheels. Under ordinary wheat belt working conditions, rubber tyred machines operating on kerosene should be rated higher than this. A tractor in good order fitted with tyres and an efficient gas plant would, perhaps, equal these figures. However, fuel consumption figures per hour for nearly all the tractors investigated are decidedly lower than they would be if the machines were developing their rated power throughout the working period.

Fuel Costs.

These are the costs of the fuel landed on the farm. For kerosene the majority paid between 1s. 2d. and 1s. 4d. per gallon.

TABLE 1.—*Costs of Operation of Producer Gas and Kerosene Tractors in Western Australia, 1938-39.*

Type of Tractor.	No. of tractor.	Rated drawbar horsepower.	Age of tractor.	Valuation at beginning of year (£).	No. of acres covered during year.	No. of hours worked.	Amount of fuel used.	Fuel per hour.	Acres per hour.	Costs (pence) per Hour of Operation.						
										Fuel.	Lubricants.	Repairs.	Depreciation.	Interest.	Labour.	Total.
Producer Gas	26	13·07	Old machine	298	2,318	1,232	21,300 lbs.	17·6 lbs.	2·0	4·5	2·9	2·5	18·1	3·8	23·3	55·1
	33	19·26	Old machine	212	3,648	1,101	23,635 lbs.	22·1 lbs.	3·3	10·3	2·3	14·6	13·4	3·3	17·1	61·0
	38	26·28	3 years	340	3,610	1,174	570 bags	0·5 bag	3·2	13·0	3·4	2·4	16·2	5·9	18·7	59·6
	42	17·59	9 years	200	1,749	732	290 bags	0·4 bag	2·4	6·7	2·8	7·0	13·6	4·0	15·8	49·9
	43	19·26	10 years	254	2,700	836	19,000 lbs.	23·0 lbs.	3·2	6·5	2·4	3·2	18·3	5·0	20·0	55·4
	44	26·44	New machine	604	4,844	1,260	577 bags	0·5 bag	4·1	3·6	1·6	2·3	20·4	6·9	16·0	50·8
	45	19·26	Old machine	337	2,749	794	16,425 lbs.	20·7 lbs.	3·4	9·4	3·1	8·6	22·7	6·1	24·8	74·7
							gals.	gals.								
Kerosene	8	19·23	New	502	2,316	1,470	2,316	1·6	2·9	26·8	2·5	3·3	14·2	5·1	22·5	74·4
	11	26·44	1 year	436	2,682	652	1,184	1·8	4·1	28·0	3·8	0·2	21·8	10·6	20·9	85·3
	13	22·48	5 years	237	5,814	1,364	2,588	1·9	4·3	28·3	5·5	4·3	11·4	4·1	22·5	76·1
	14	17·15	New	430	2,795	1,063	1,466	1·4	2·7	23·9	3·8	—	15·5	6·1	17·4	66·7
	40	26·28	3 years	372	3,271	918	1,487	1·6	3·6	26·7	3·3	0·7	18·0	7·3	18·8	74·8

Charcoal costs varied considerably. One man who burnt charcoal with hired labour from waste timber on his farm had costs of under 4d. per hour for fuel. Where it was necessary to buy charcoal and rail it some distance, costs were considerably higher.

Fuel costs for both kerosene and gas tractors include a charge for petrol for starting.

The marked savings which can be effected in fuel costs by converting from kerosene to producer gas are very well illustrated in this column.

Lubrication.

Lubrication charges consist mainly of costs of engine oil. Here again producer gas shows to advantage.

Repairs.

These have been charged at the actual cost to the farmer of spare parts and expert labour. Farm labour has been charged at 1s. 3d. per hour. These figures are not quite a fair comparison as several of the producer gas tractors are old and would probably be rather costly for repairs even if operated on kerosene.

Depreciation.

The method used for computing depreciation is based on a suggestion by an American writer.* The normal life of a tractor in which it depreciated from new price to three per cent. of its original value is assumed to be 10 years, when worked for 1,000 hours per year. Part of the yearly depreciation is charged irrespective of work done, and the remainder is directly proportionate to the work performed. Tyres and producer gas units have been depreciated at double this rate. In the case of reconditioned tractors fitted with tyres and gas plants, a total life of five years and 1,000 hours per year has been assumed. The value of all tractors at the commencement of the 12-month period was calculated as nearly as possible by this method, and naturally includes the value of gas plants, tyres, etc.

Interest.

This was calculated at six per cent. on the average between the new price and the value at the commencement of the period for which records were kept.

* Jasny. Research Methods on Farm Use of Tractors. Columbia University Press, 1938.

Labour.

This includes the labour of the tractor driver and that of any other persons on the machines attached to the tractor, and charged at 1s. 3d. per hour. In addition, daily attention has been charged at the same rate, and the total amount for the year divided by the number of hours worked and added to the cost per hour of operation. This is in order to place the producer gas tractor on the same footing as other types which require rather less attention.

Work Performed.

The operations performed during the year covered the normal activities associated with cereal production. For the 46 tractors included in the survey, the areas covered for each operation (expressed as percentages of the year's total) are set out in Table 2.

TABLE 2.—*Types of Work Performed by Tractors expressed as Percentages of Total Acreage Covered.*

Implement.	Percentage of Total Acreage Covered.	
Ploughs—		
Mouldboard	2·8	
Disc	1·3	
Disc cultivating	17·9	
		22·0
Cultivators—		
Spring tyne*	12·3	
Rigid tyne scarifier	22·5	
Harrows	2·6	
		37·4
Seeding implements—		
Disc drill	3·0	
Spring tyne combine	12·2	
Trip tyne combine	3·9	
"Sunder-seeder" type combine	1·4	
		20·5
Harvesting machinery—		
Harvesters	12·7	
Headers	6·1	
		18·8
Miscellaneous—		
Binders	0·3	
Scrub rollers	1·0	
		1·3
Total		100·0

* Both as ordinary cultivator and as combine.

Non-effective Associations of Nodule Bacteria and Legumes

WITH PARTICULAR REFERENCE TO THE INFLUENCE OF THE HOST PLANT

By

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At one time it was considered that there was only one bacterial species producing nodules on the roots of legumes, viz. *B. radicicola*. Nowadays, however, several distinct species are recognized on the basis of plant infection, serological tests and cultural characteristics. The organism producing nodules upon the genera Medicago, Melilotus and Trigonella, for example, is *Rhizobium melilotus*, while that producing nodules upon the genera Pisum, Vicia, Lathyrus and Lens is *R. leguminosarum*. Although these specific distinctions are now drawn, several workers have shown that distinctive strains occur within these species. This strain variation is very important from the agricultural point of view, and it is the nature of this variation and the factors which influence it that today are occupying much of the attention of investigators of legume symbiosis.

Occurrence and Characteristics of "Non-effective" Nodulation.

At first it was generally believed that if the organism invaded the plant and formed nodules, other things being equal, there would be adequate fixation of elemental nitrogen. Beijerinck, in the eighties of last century, suggested, however, that the association of plant and bacteria may not always be mutually beneficial and he recognized two broad classes—one in which the plant gains ascendancy, and the other in which the bacteria are stronger, destroying the plant tissues and acting as parasites. In 1893, Nobbe and Hiltner, pioneers in the field of legume inoculation, also stated that the organism may not always be beneficial to the host plant, and pointed out that this must be taken into consideration in field inoculation. In 1925, it was shown by Stevens[1] at Wisconsin that strains of the lucerne organism varied greatly in their effectiveness. They could be differentiated into broad groups by means of serological tests, and there was a big difference in their effects upon the growth of the host plant grown under pot conditions with no other sources of nitrogen than those produced by bacterial activity. Wright[2] working with the soybean organism, obtained similar results. Since then research workers in various parts of the world have obtained results which show a wide variation in the effectiveness of strains of the various rhizobial species.

From 1930 onwards, references to the occurrence of " parasitic " or non-effective strains have been made. Thornton[3] has investigated parasitic strains, particularly of the clover organism, and Leonard[4] in 1930 described the failure of a crop of Austrian winter peas which, though displaying the symptoms of extreme nitrogen deficiency, had large numbers of small nodules upon their roots.

The characteristics of the association of the legume and non-effective or parasitic strain of Rhizobium are well known. Numerous, typically small, hard nodules are produced and the plant displays the symptoms of nitrogen deficiency. A most striking feature is the fact that continuous infection and nodulation occur over the whole root system, which contrasts with the nodulation produced by an effective strain, when large bunches are produced, usually near the crown and proximal portions of the secondary roots with comparatively few scattered nodules elsewhere. In the effective type of nodulation a resistance by the plant to further infection and nodulation appears to be set up after the early infection. The narrowing of the carbohydrate : nitrogen ratio within the plant is regarded as an important factor in the apparent resistance which is produced. Many features of the mechanism of fixation and supply of nitrogen to the plant remain unsolved, but much light has been thrown upon the occurrence of so-called non-effective strains by recent investigations of the influence of the host plant.

The Influence of the Host Plant.

Until recently, non-effective or parasitic strains have been referred to as though inability to fix nitrogen was a fixed, innate quality of the strain itself. It appeared that further information would be forthcoming only if we could grow the organism in culture where it would fix nitrogen, when differences in innate ability to fix nitrogen could be tested. However, in recent years the occurrences of strains effective with one host but non-effective with another species belonging to the same cross-inoculation group, have been reported. It has been shown that pure strains of *Rhizobium trifolii* from subterranean clover, highly effective with that plant, produce non-effective nodulation upon white and red clover, and, *vice versa*, strains effective with the latter host plants have proved non-effective with subterranean clover. Studies of the organism for the lucerne and the pea and broad bean groups have also been made, and within these groups the host plant has proved the important factor influencing strain effectiveness. Pure strains of *R. meliloti* from lucerne have produced non-effective nodules upon King Island melilot (*Melilotus indica*), but the few strains from *M. indica* that have been tested have proved effective upon both lucerne and melilot. The effects on growth of these two plants can be observed in Fig. 1. In regard to the relationships of strains from the burr medic (*M. denticulata*) and lucerne (*M. sativa*), though the degree of effectiveness

Figure 1.

Plants inoculated with a strain of *Rhizobium meliloti* isolated from lucerne. The deep green plant in the centre is lucerne which has effective nodules; the small, yellowish plants on the outside are King Island melilot which have non-effective nodules.

has varied with the host plant, all strains so far tested from the one have proved at least partially effective upon both species. This is quite significant from the agricultural point of view on account of the wide distribution of burr medic in areas suitable for lucerne.

The host plant factor is also proving important in relation to the effectiveness of strains of *Rhizobium leguminosarum*. Strains isolated from either the broad bean (*Vicia faba*) or field pea (*Pisum sativum*) have proved to be highly effective upon both these host plants, but a strain isolated from the wild vetch (*Vicia sativa*), while effective with the field pea, only produces non-effective nodules upon broad bean. Thus a strain may be effective on the one hand with both *Vicia faba* and *Pisum sativum*, whilst another strain from a different host plant of the genus Vicia may be effective with a host of the genus Pisum but non-effective with another species of the genus Vicia.

Recent results at Wisconsin, too, have indicated that host plant "specificity" is an important factor governing the effectiveness of strains of the organism for lucerne.

From the results so far obtained, the existence of a strain, parasitic or non-effective in the absolute sense, is doubted. Strains which have been

recorded as such in the past may prove effective if the appropriate host plant is found. So far none of the strains studied at the Waite Institute have proved non-effective with all the host plants tested.

To what extent the behaviour of the strain remains fixed or is changed by continuous association with a particular host plant, is a question which has not yet been completely answered. Experiments at Wisconsin[5] have suggested that the effectiveness of a strain may be changed by repeated passage through the host plant. A complete investigation of this aspect of the subject would demand consideration of the possibilities arising from variation and selection or adaptation. It is obvious that a sufficiently large sample of any bacterial population would need to be tested for uniformity or extent of variation before an accurate interpretation of strain behaviour, particularly if it is changing, could be made. When can a strain be considered pure ? Is it ever fixed in such a way that " mutation " alone can produce a change in behaviour towards a particular host plant ? It appears that after continuous association of a population of *R. trifolii*, for example, with a particular host plant such as subterranean clover, the strain most likely to be isolated by the method of repeated plating is one which is peculiarly adapted to that host and which, temporarily at least, is non-effective when introduced to white clover. Yet strains which are at least partially effective upon both hosts can be produced. Do these comprise a mixed population not completely adapted to either host ?

This subject is of particular importance from the field aspect. If adaptation or " mutation " and selection act freely it is likely that the occurrence of non-effective strains in the field would be only temporary, for a population adapted to the new host would soon be evolved. This may explain the fact that the occurrence of legumes with the typical non-effective nodulation has not yet been observed in the field in South Australia.

Competition or Antagonism of Strains.

The possible antagonism of non-effective and effective strains is an important consideration from the point of view of practical agriculture. Sometimes a particular host plant, artificially inoculated with its effective rhizobial strain, is introduced into areas where naturalized or native host plants of the same cross-inoculation group carrying a rhizobial strain non-effective with this host plant are already present. A naturally occurring parasitic strain of the clover organism was reported to militate against the successful establishment of white clover in the hills of Wales.[3] In experiments at Rothamsted, this strain proved to be antagonistic towards some effective strains and in some cases when present, either within the roots or the rhizosphere, inhibited to some extent infection by effective organisms. However, an effective strain which could compete successfully with this strain was eventually found.

Experiments at the Waite Institute were designed to test the effects of the presence of non-effective strains upon inoculation of the host plant with effective strains. Using subterranean and white clover as hosts, the effective strains asserted themselves when both types of strains were introduced together at planting time. When the non-effective strains were introduced at planting time and the effective strains three weeks later, a small depression in yield in comparison with plants inoculated with effective strains only at planting time was recorded. When the effective strain was not introduced until 6 to 7 weeks after the initial inoculation with the non-effective strain, a considerable depression in yield was recorded.

Similar results were obtained with the tick bean as host, when the normally effective and the non-effective vetch strain of *R. leguminosarum* were used. Plants in the presence of the non-effective strain displayed the symptoms of nitrogen deficiency at five weeks but, after the introduction of the effective strain, recovered to some extent.

The root systems bore numerous ineffective nodules, but on the distal portions extra large nodules of the effective type were developed (see Fig. 2). The results obtained indicated that, with the particular strains experimented with, effective strains, when present in sufficient numbers, asserted themselves in the presence of non-effective strains.

For the development of the practice of artificial seed inoculation it is obvious that strains of a given species must be tested with all host plants of the cross-inoculation group for which they are to be used. In some cases effective

Figure 2.

A distal portion of the root system of the broad bean, showing nodule produced by an effective strain introduced 6-7 weeks after the root system had been inoculated with an effective strain (note the numerous small nodules on others).

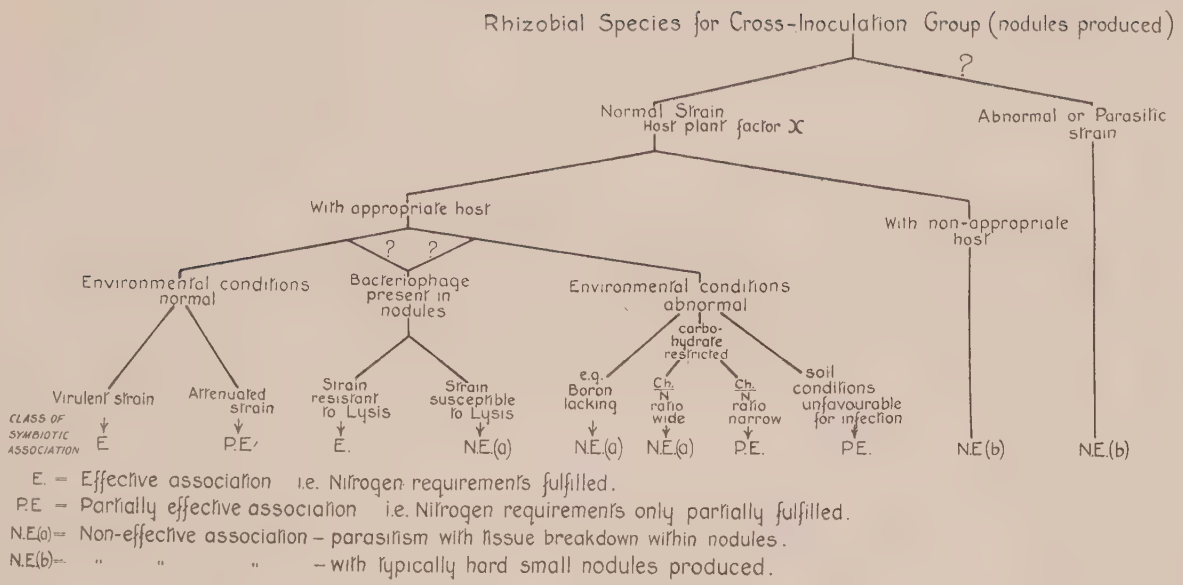

Figure 3.

Diagram showing recognised Types of Association.

strains may be blended, in others it may be necessary to maintain separate cultures. In South Australia, it has not proved difficult to obtain effective strains which will compete successfully with non-effective strains.

Other Factors which Influence Effectiveness of the Association.

From the previous discussion it appears that some host plant factor determines whether a rhizobial strain of the species for the particular cross-inoculation group is effective or non-effective. In the presence of the appropriate host a strain may be highly effective or partially effective, depending upon its virulence. Normally, effective strains may become parasitic under particular environmental conditions, such as when the supply of carbohydrate to the nodules is restricted by shading, or when an element such as boron, for example, is lacking.

The occurrence of bacteriophage within the nodule is of particular interest, and whilst Demolon[6] believes that its appearance within the lucerne nodule induces nodule breakdown followed by host plant decline, other workers believe its presence to be a normal nodular phenomenon. Whilst particular strains may be susceptible to lysis, resistant strains develop naturally, and a particular set of environmental conditions only can produce the condition of phage dominance described by the Frenchman. The problem is obviously worthy of further research, particularly in connection with the well known phenomenon of clover " sickness ".

Finally, soil conditions exert a profound influence over the activities of rhizobium and the production of nodules. Soils deficient in lime are particularly unfavourable to the activities of Rhizobium, and under such conditions nitrogen deficiency of the host plant may be coincidental with other deficiencies.

The accompanying diagram (Fig. 3) has been drawn up to show the various types of symbiotic association which have been discussed. It is suggested that the abnormal strain parasitic in the absolute sense is of doubtful occurrence. The host plant factor is shown to be of primary importance in determining whether the association is effective or non-effective. Some of the experimental evidence that has been produced does not justify a rigid classification of the association of strain and non-appropriate host as of non-effective type, as this association sometimes appears to be partially effective. This may be due to the fact that the strain is not pure or completely adapted to a particular host. Whether the association of normal strain with appropriate host plant is effective, partially effective or non-effective, is determined by a number of factors. The chief of these is probably the soil, for in many cases, such as, for example, where there are deficiencies of such nutrients as lime and phosphate, the association may be of the partially effective type.

(1) Stevens, J. W. Soil Sci., 20 : 1925.
(2) Wright, W. H. Soil Sci., 20 : 1925.
(3) Thornton, H. C. Rothamsted Repts., 1936-38.
(4) Leonard, L. T. Jour. Amer. Soc. Agron., 22 : 1930.
(5) Allen, O. N., and Baldwin, I. L. Wis. Agr. Expt. Sta. Research Bull. 106, 1931.
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Mycorhizæ and Growth of Pinus and Araucaria

THE INFLUENCE OF DIFFERENT SPECIES OF MYCORHIZA-FORMING FUNGI ON SEEDLING GROWTH

By

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During the course of investigations concerning fused needle disease of Pinus in Queensland, the view was taken that the problem was one which was bound up with the mycorhizal complex of the trees concerned. Among other aspects of this conception, some consideration was given to the possibility that different species of the fungal symbionts might cause a different growth reaction in the trees concerned in the root-fungus partnership. It was thought possible that some species of fungi might, under the conditions prevailing in Queensland, bring about better results as regards tree growth than others, and that if such a fungus could be found, the inoculation of a forest nursery with this species would be of definite economic value. The chance of obtaining such an organism would be much greater in the case of exotic species, such as *Pinus caribæa* and *P. tæda*, than in the case of the endemic *Araucaria cunninghamii*. All three tree species are extensively used in plantation work in Queensland.

Experiments with Pinus caribæa.

In order to gain some data on this hypothesis so far as *P. caribæa* was concerned, an experiment was designed and carried out at the forest nursery at Beerwah in southern Queensland. A collection of seven fungi known to be mycorhiza formers in other parts of the world, was obtained from two sources : the " Centraalbureau Voor Schimmelcultures " in Holland, and Dr. H. R. A. Muller of Java. Those obtained from the first source included *Boletus viscidus*, *B. scaber*, *B. luteus*, *B. bovinus*, *B. elegans* and *Russula* sp. The fungus *B.* (?) *granulatus* was an isolation obtained from Dr. Muller who found it associated with *P. merkusii*. In no case was any of the fungi obtained from the species of conifer experimented with in Queensland. *Russula* sp. was isolated from the larch in Europe.

Preliminary experiments were first carried out in the laboratory to determine whether these fungi could form mycorhizæ with *P. caribæa* and *P. tæda*. The method followed was that used by Melin, and consisted in growing sterile seedlings on a substratum of sand and nutrient solution in sterile Erlenmeyer flasks. All the fungi used, including local isolations of

B. granulatus and *Rhizopogon roseolus*, formed typical mycorhizæ with both species of Pinus.

For the purpose of nursery inoculations, adequate quantities of inoculum containing pure cultures of each of the respective species of fungus were prepared by growing the fungi in two-litre Erlenmeyer flasks on a sterilised compost consisting of unhusked oats moistened with 2 per cent. malt extract. It had been found previously that the addition of malt extract produced a more vigorous growth of the fungi. When the oat compost was well penetrated by the fungus, it was considered to be suitable for inoculation purposes.

Containers for growing pine seedlings were made from blackbutt timber (*Eucalyptus pilularis*). Each container consisted of a box two feet wide, four feet long and one foot deep. The containers were placed eighteen inches apart on a stand two feet six inches above the ground in a position sheltered from winds, but otherwise open. The boxes were filled with nursery soil which was well mixed so as to ensure that the same constituents were put in each. One and a half cubic feet of unrotted cowdung and two-fifths of a cubic foot of pine needles were then added to each box and mixed with the top four inches of soil. These latter constituents were added in order to ensure the presence of adequate supplies of organic matter for the support of the mycorhizal fungi. Nine boxes were prepared in this way, and, with their contents, were sterilised by saturating them with a 2 per cent. formalin solution and keeping them covered with hessian bags for three days.

On September 3, 1937, fourteen days after sterilisation, all the boxes were sown with moist, cold-stored seed of *P. caribæa*. Before sowing, the seed was sterilised by washing in a mercuric chloride solution (1 : 1000). The seed was sown in drills at the rate of twenty-four seeds per foot of drill. There were six drills, each two feet long, in every box.

One week after the seed was sown, the soil in the boxes was inoculated with the fungus cultures previously prepared. The inoculation was carried out by making drills at a distance of one and a half inches from, and parallel to, each seed drill and filling them with the oat inoculum which was then covered with soil. A control box was inoculated with mycorhizæ obtained from beneath a healthy stand of *P. caribæa*, both *B. granulatus* and *R. roseolus* probably being present. This inoculum was not a pure culture. Two days later, the fungi from the oat inocula were observed growing through the surface soil covering the drills, and the first pine seedling was above ground on the following day. The seed germinated evenly in all the boxes and the resulting plants were thinned out so as to leave an average of forty-four seedlings to each two-foot drill of the experiment.

Results.

When the season's growth had ceased and the plants had entered the dormant stage (May 20, 1938) the heights of all the seedlings in the various

boxes were measured and recorded. The results of the measurements are shown in the accompanying table.

Mean Heights and Weights of Pinus caribæa *Seedlings Inoculated with Different Mycorhizal Fungi.*

Species of Fungus.	Number of Seedlings.	Mean Height in Inches.	Standard Error.	Mean Weight in Grammes.
(1) *Boletus viscidus*	202	15·23	0·17	14·63
(2) *B. scaber*	213	14·99	0·17	12·95
(3) *B. luteus*	202	14·84	0·16	11·21
(4) *B. bovinus*	200	14·82	0·16	14·19
(5) *B. elegans*	223	14·55	0·15	10·79
(6) *Russula* sp.	228	13·51	0·14	9·78
(7) *Boletus* (?) *granulatus* ..	190	13·21	0·15	12·92
(8) Control (*B. granulatus* and *Rhizopogon roseolus*) ..	194	13·07	0·15	9·31

Total mean height: 14·28 inches.
Total mean weight: 11·97 grammes.

Boletus viscidus gave the best result and was significantly superior to *B. elegans*, *Russula* sp. and *B.* (?) *granulatus*, though not significantly superior to *B. scaber*, *B. luteus* and *B. bovinus*.

The difference in height produced by *Russula* sp. and the control= 0·44±0·205, which is significant. The difference between *B.* (?) *granulatus* and the control is not significant. This is interesting in that the inoculum used in the control contained *B. granulatus*. A box containing a pure culture of the local *B. granulatus* unfortunately, due to a mishap, had to be discarded and so no true comparison between these two fungi could be made.

The measurements indicate that different mycorhiza-forming fungi as represented by the species used in this experiment, may vary considerably in their capacity for stimulating growth in one species of tree associate. All the exotic fungi used, with the exception of *B.* (?) *granulatus*, gave a significant response in seedling height growth at ten months of age when compared with the normal local mycorhizal complex as exhibited by the control. However, owing to the unfortunate elimination of the box containing the pure culture of the local *B. granulatus*, it is not possible to disregard the possibility that the low figures for the control were due to the interaction of other microflora introduced with the mycorhizal material used. From the results obtained from *B.* (?) *granulatus*, however, this would not appear to be so. This point is being further investigated.

After height measurements were recorded, every tenth plant in each plot was collected for sampling purposes. These plants were cut off at the cotyledons and, each treatment being kept separate, dried. The roots were not used

owing to the difficulty of obtaining the complete root systems. The mean dry weight of a plant for each treatment was then determined, the results being as shown in the table. All the plants in each plot were not weighed, as it was desired to establish field plots with the inoculated plants. With the numbers sampled, however, the indications are that, save in the case of boxes 4 and 7, the weight differences are proportional to the heights. *Boletus bovinus*, which was fourth in the order of height, was second in mean weight and much superior to *B. scaber* and *B. luteus* and the lower members of the series, and for this reason is considered to be second in order of desirability.

The fact that greater growth is produced in nursery seedlings of *P. caribæa* by certain mycorhizal fungi may not be of great value in itself, as the main part of the plant's history is in the plantation. The relative effect of the various fungi on the growth of the plants in the plantation is unknown and would be hard to measure owing to the difficulties involved in keeping pure cultures of the special fungi on the roots of any one tree in the field. There is no reason to think, however, that the field behaviour would be other than that obtaining in the nursery. For the purpose of making observations on this point, blocks containing the trees produced in the experiment and which were not used for weight determinations were planted in the field at Glasshouse Mountains in 1938. No results can be expected from these plots for some years.

Experiments with Hoop Pine.

In contrast to the mycorhiza of *Pinus caribæa*, the mycorhiza of hoop pine (*Araucaria cunninghamii*) is endotrophic in form, and the exact identity of the fungus involved is as yet unknown. In pure culture experiments in Erlenmeyer flasks, hoop pine seedlings have produced mycorhizæ when grown in association with *Boletus granulatus* and also with an undetermined fungus constantly isolated from naturally occurring hoop pine mycorhizæ. The latter fungus in culture is similar to and possibly identical with *B. granulatus*, in which case no differences in reaction would be expected. Hoop pine seedlings failed to develop in pure culture without the presence of a mycorhizal fungus.

Field experiments were carried out at Yarraman forest nursery on the same plan as those at Beerwah, using the two abovementioned fungi. In addition, unsterilized nursery soil containing the natural hoop pine mycorhiza-forming fungus was used as a control. Sterilisation of the soil in the boxes used for the pine cultures was carried out with formalin as in the other experiment, and the seed sowing and fungus inoculation procedures were similar.

Twelve months after sowing, at the time at which hoop pine seedlings are normally transplanted in nursery practice, observations recorded showed that there was no difference in the development of the plants which could be

attributed to the different inoculations. It was concluded that under the conditions of the experiment and with the fungi used, no different effect was produced by the two organisms.

It is of interest to note that both in the flask and the box experiments, the fungi used produced endotrophic mycorhizæ with hoop pine. With Pinus, *B. granulatus* produces ectendotrophic mycorhizæ. It would appear in this connexion that with the *B. granulatus*-Pinus and *B. granulatus*-Araucaria associations, the nature of the mycorhizæ is a host, rather than a fungus, reaction.

Internal Grain Infection and Kernel Rot in the 1938 American Maize Crop

By

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In the decade prior to 1930 a number of investigators[1, 2, 3, 12, 13, 14, 15, 16, 17, 19] surveyed the nature and extent of internal seed-borne infection in maize in various parts of the United States of America, but in recent years American workers have paid little attention to this aspect of maize pathology. The writer[4, 5] has shown that a high degree of internal infection was of common occurrence in maize used for seed purposes in New South Wales, and that several of the organisms occurring in this manner were the main causes of seedling blight diseases under local conditions.

A survey of the relative prevalence and geographical distribution of kernel rotting fungi in the American maize crop has been made each season since 1933 by Hoppe and Holbert[9, 10, 11] or Hoppe.[6, 7, 8] The material on which the survey is based consists of damaged kernels taken by grain inspectors at terminal markets from carload lots of known origin. These samples, together with a sample of the commercially sound grain from each carload, are forwarded to the Chicago office of the Federal Grain Supervision Service, Bureau of Agricultural Economics, U.S. Department of Agriculture. The samples of both sound and damaged grain are then forwarded to Mr. P. E.

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Hoppe* at the University of Wisconsin, Madison, Wis., where isolations are made from the damaged kernels.

It occurred to the writer that the sound grain samples would provide excellent material for investigating the nature and prevalence of internal grain infection over a wide geographical range, and that the results considered in conjunction with those of the kernel rot investigations would provide some definite information on the regional relationships of the two types of infection. Accordingly arrangements were made whereby the writer took over all the samples of sound grain from the 1938 crop, and, in addition, Mr. Hoppe very kindly consented to permit the writer to examine and record all the isolations which were made from the rotted kernels. This examination was carried out subsequent to and quite independent of the examination which Hoppe made in connection with his investigations, as it was considered desirable for comparative purposes that the person recording the internal infection should also record the kernel rot.

In the course of this survey all the available samples of commercially sound grain were not utilised. The results of the isolations from the rotted separates were determined in each case prior to plating of the corresponding sound grain, and in those instances where the number of rotted kernels was less than 25, the corresponding sound samples were discarded.

A uniform number of 50 kernels from each sound sample was used for isolation purposes, and in all cases care was taken to discard any kernel which showed external evidence of rotting or other injury. The kernels were surface sterilized by immersion for 15 minutes in a 1 : 10 aqueous solution of B.K. (3·5 per cent. sodium hypochlorite). The basal portion of each kernel was then removed aseptically and transferred direct to potato dextrose agar. Five kernel tips were plated in each petri dish and the plates were incubated at 25° C. for a period of 5 to 7 days before the records were taken.

These investigations were carried out at the University of Wisconsin during the first quarter of 1939. Records of both kernel rot and internal infection were secured from samples representing 183 carloads of maize from 12 different States. The results of the isolations arranged on a State basis are given in Table 1.

Discussion of Results.

The data concerning the ear rot survey for the 1938 crop have already been published by Hoppe[8] and will not be discussed in this paper, except insofar as it is necessary in order to consider the relationship between the nature and incidence of kernel rot and that of internal seed-borne infection for any particular region.

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TABLE 1.—*The Nature and Incidence of the Organisms causing Kernel Rot and Internal Grain Infection in the 1938 Maize Crop in United States of America.*

Origin of Samples.	No. of Samples Examined.	No. of Kernels Plated.	Type of Infection.	No infection.	*Diplodia zeae.*	*Gibberella zeae.*	*Gibberella fujikuroi.*	*Fusarium* spp.	*Nigrospora sphaerica.*	*Cephalosporium acremonium.*	*Penicillium* spp.	Miscellaneous Fungi and Bacteria.
				%	%	%	%	%	%	%	%	%
Atlantic States—												
Maryland	29	1,310	Kernel rot ..		40·0	16·1	19·5	3·3		0·2	1·6	19·2
		1,450	Internal ..	19·3	5·0	16·7	25·7	1·2	3·2	12·5	0·9	14·8
Delaware	4	164	Kernel rot ..		46·9	17·1	20·1	0·6		0·6	1·2	13·4
		200	Internal ..	23·5	5·5	13·0	23·5	1·0	3·5	16·5	1·5	12·0
East-Central States—												
Ohio	3	94	Kernel rot ..		51·1	3·2	10·7	10·6				24·4
		150	Internal ..	46·6	2·0	6·0	4·7		27·3	3·3		10·0
Indiana	21	788	Kernel rot ..		64·5	5·3	13·0		0·7		8·3	8·1
		1,050	Internal ..	55·8	7·2	2·3	6·2	0·8	8·2	4·6	5·0	9·6
Illinois	27	1,071	Kernel rot ..		69·8	3·1	16·3	0·6	0·1		4·2	5·8
		1,350	Internal ..	55·3	7·1	1·2	7·6	0·3	11·2	5·6	1·2	10·3
West-Central States—												
Minnesota	13	585	Kernel rot ..		4·7	1·2	38·6	18·9	2·6		17·4	32·8
		650	Internal ..	30·4	0·5	0·8	22·1	0·8	13·9	6·9	9·4	14·2
Iowa	26	1,055	Kernel rot ..		11·5	1·4	70·7	0·9			1·8	12·9
		1,300	Internal ..	34·5	1·3	1·5	26·8	0·3	4·2	20·6	0·7	10·0
Missouri	13	524	Kernel rot ..		12·0		79·3	0·2	0·5	0·4	1·3	6·6
		650	Internal ..	22·6	0·3		46·8	0·2	0·6	25·1	1·0	3·4
Western States—												
Nebraska	31	1,499	Kernel rot ..				89·9	0·3		0·1	2·9	6·3
		1,550	Internal ..	18·4			57·1	0·8	0·5	14·7	1·8	6·7
Kansas	9	306	Kernel rot ..				90·5	0·6			2·9	5·9
		450	Internal ..	27·8			38·5	0·5	0·9	25·6	1·3	5·3
Colorado	4	151	Kernel rot ..				91·4	1·3				7·2
		200	Internal ..	49·5			41·0	1·0		3·5		5·0
Southern State—												
Tennessee	3	121	Kernel rot ..		42·9		54·5					2·5
		150	Internal ..	16·6	2·7		41·3	0·7		26·7	0·7	10·6

The combined survey showed that *Diplodia zeae* (Schw.) Lev. was the most prevalent ear rotting organism in Illinois, Indiana, Ohio, Delaware and Maryland and was responsible for 69·8, 64·5, 51·1, 46·9 and 40·0 per cent. of the total infection occurring in these respective States. The fungus, however, was relatively infrequent as an internal seed-borne organism, its relative frequency in these States being 7·1, 7·2, 2·0, 5·5 and 5·0 per cent. respectively. This finding is in general agreement with previous work[1, 2, 3, 4, 13, 15] on the occurrence of *Diplodia zeae* internally in maize grains. It is of interest to note that *Diplodia zeae* was not recorded from the western States—Kansas, Nebraska and Colorado.

Gibberella zeae (Schw.) Petch was relatively prevalent as a kernel rotting organism in Delaware and Maryland, being responsible for 17·1 and 16·1 per cent., respectively, of the total rotting. In Indiana, Ohio, Illinois, Iowa and Minnesota it was much less prevalent, its incidence being 5·3, 3·2, 3·1, 1·4 and 1·2 per cent. respectively. The organism was not recorded from Missouri, Nebraska, Kansas, Colorado or Tennessee. Its frequency as an internal organism in Delaware and Maryland was approximately the same as it was for kernel rot, but elsewhere it was of minor importance only, although an average of 6 per cent. infection was recorded in the three samples from Ohio.

Both *Diplodia zeae* and *Gibberella zeae* are usually vigorous pathogens, and infection of the ear or kernel normally results in obvious rotting of the tissues, which enables infected material to be recognized readily by macroscopic examination. For this reason, neither of these organisms is usually prevalent in ears which have been selected for seed purposes. The relatively high incidence of *Gibberella zeae* as an internal seed-borne organism in the Atlantic seaboard States is particularly interesting. It must be remembered, however, that the grain samples from which isolations were made in the present survey had not been selected for seed purposes, but were ordinary commercial lots of grain, and it is probable that much of the grain found to be infected internally was derived from ears that were partially rotted by the fungus. It is interesting to note, however, that Manns and Adams[13] in 1923 reported that seed maize in Delaware showed an incidence of 5·95 per cent. of internal infection with *G. zeae*.

Gibberella fujikuroi (Saw.) Wr. was the only fungus recorded as a kernel rotting organism in all States. It was also the only fungus which occurred in all States as an internal seed-borne organism. It was the most important cause of kernel rot in Colorado, Kansas, Nebraska, Missouri, Iowa, Tennessee and Minnesota, being responsible for 91·4, 90·5, 89·9, 79·3, 70·7, 54·5 and 38·6 per cent., respectively, of the total infection in these States. In Tennessee, however, *Diplodia zeae*, with an infection incidence of 42·9 per cent., was almost as important. The degree of internal infection due to *Gibberella fujikuroi* ranged from 57·1 per cent. in Nebraska to 4·7 per cent. in Ohio. It was the most prevalent internal organism in all regions except the east-

central States—Ohio, Indiana and Illinois—where in each case both Nigrospora and miscellaneous fungi were more prevalent.

The miscellaneous Fusaria mainly consisted of species of the sections Sporotrichiella and Arthrosporiella, but for the sake of convenience the fusarial stage of *Gibberella fujikuroi* var. *subglutinans* was also included under this heading. This fungus was not of common occurrence in the material examined but it was recorded in all States except Delaware, and was also isolated a number of times from apparently sound maize grown at Madison, Wisconsin. The occurrence of this organism in the United States was first recorded by Ullstrup[18] in 1936, who found perithecial material on old maize stalks in New Jersey and Ohio and considered that it was probably a recent introduction.

Nigrospora sphaerica (Sacc.) Mason was unimportant as a cause of kernel rot, the maximum infection of 2·6 per cent. occurring in the Minnesota material. It was much more prevalent as an internal seed-borne organism, and in six States this was its only manner of occurrence. It was the most prevalent internal organism in Ohio (27·3 per cent.) and its incidence was also relatively high in Minnesota, Illinois and Indiana, being 13·9, 11·2 and 8·2 per cent., respectively.

Cephalosporium acremonium Corda was associated only rarely with kernel rot, but it occurred as an internal seed-borne organism in all States and was most prevalent in Tennessee, Kansas, Missouri and Iowa where its incidence was 26·7, 25·6, 25·1 and 20·6 per cent., respectively, and where it ranked next in prevalence to *Gibberella fujikuroi*. It was somewhat less prevalent in Delaware, Nebraska and Maryland where infection percentages of 16·5, 14·7 and 12·5, respectively, were recorded.

Penicillium spp. were relatively prevalent in two States only, 17·4 and 8·4 per cent. of kernel rot due to these fungi being recorded from Minnesota and Indiana. The corresponding figures for the internal infection were 9·4 and 5·0 per cent., respectively.

In certain States such as Minnesota, Ohio, Maryland, Delaware and Iowa, miscellaneous fungi were an important factor in producing kernel rot, and were responsible for 32·8, 24·4, 19·2, 13·4 and 12·9 per cent., respectively, of the total damage. They likewise commonly occurred as internal seed-borne organisms, and the incidence of such infection for the foregoing States was 14·2, 10·0, 14·8, 12·0 and 10·0 per cent., respectively. Internal infections of more than 10 per cent. were also recorded from Tennessee and Illinois. The miscellaneous fungi principally consisted of *Rhizopus* spp., *Chaetomium* sp., *Trichoderma* sp., *Aspergillus* spp., *Aspergillus niger*, *Cephalothecium roseum* and a number of unidentified types. *Trichoderma* sp. was commonly isolated from Iowa, Minnesota, Nebraska and Maryland; *Chaetomium* sp. was most prevalent in samples from Illinois, Minnesota, Iowa and Ohio. *Rhizopus* spp., *Aspergillus* spp. and *Cephalothecium roseum* occurred mainly in samples from Minnesota. An unidentified sterile fungus reported by Hoppe[7] in 1938 was

again fairly prevalent in samples from Maryland and Delaware, and was also found to occur in several other States. This fungus occurs both as a kernel rotting and as an internal seed-borne organism.

In considering the relation of kernel rot to internal seed-borne infection, it must be realized that the organisms which invade maize ears consist of two rather distinct types. As a general rule, both *Diplodia zeae* and *Gibberella zeae* are vigorous pathogens and infection by these organisms is typically followed by pronounced rotting of the tissues. On the other hand, organisms such as *Gibberella fujikouroi*, *G. fujikuroi* var. *subglutinans*, *Nigrospora sphaerica* and *Cephalosporium acremonium* are not vigorous pathogens, and infection with these fungi may not cause the production of any visible symptoms by which such infection can be recognized.

Results of the survey show that in States such as Colorado, Kansas, Nebraska, Missouri and Iowa, where *G. fujikuroi* was most prevalent as a cause of kernel rot, this fungus was likewise the most prevalent internal seed-borne organism.

The results for *Diplodia zeae*, however, were entirely different, as in those States such as Illinois, Indiana, Ohio, Delaware and Maryland where it was the most common cause of kernel rot, it was relatively unimportant as an internal seed-borne organism. The results obtained from many individual samples from these States showed that it was not uncommon for *D. zeae* to be very prevalent as the cause of kernel rot, while the corresponding samples of sound grain from the same locality were heavily infected internally with *G. fujikuroi*.

In Maryland and Delaware, where *G. zeae* was relatively common as a cause of kernel rot, it was likewise fairly prevalent as an internal grain organism. It is considered probable, however, that the grains infected internally with this fungus were derived from ears showing definite symptoms of ear rot, as there is a good deal of evidence to show that *G. zeae* is of rare occurrence in ears which show no obvious symptoms of infection.

In the case of both *Cephalosporium acremonium* and *Nigrospora sphaerica*, there was no correlation between kernel rot and internal grain infection. The former organism is only doubtfully pathogenic, and although it was fairly common as an internal organism, it was rarely associated with kernel rot. *Nigrospora sphaerica* is likewise not very common as a cause of kernel rot, but it sometimes invades the ears and usually causes a more or less severe rotting of the cob tissues. It is probable that internal infection with this fungus becomes established as a result of cob invasion, in many cases where no actual grain rot occurs.

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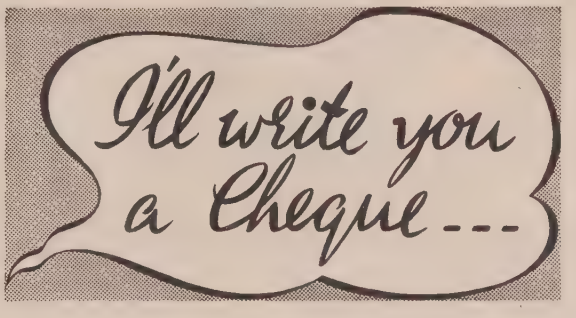

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The Analysis of Quasi-Factorial Designs with Incomplete Data

By

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In recent years Yates[5, 6, 7] has developed the quasi-factorial designs for the special purpose of testing large numbers of treatments, for example, varieties of a crop in agricultural trials. These designs are of three types, namely, quasi-factorial designs in randomized blocks, balanced incomplete blocks and quasi-Latin squares, each of which is characterized by a special arrangement of the treatments within the groups of units (blocks) into which the experimental material is divided. The several types of symmetrical arrangement are such that they facilitate the elimination of group differences from the treatment comparisons and, at the same time, easily lend themselves to statistical analysis.

In cases where some of the observations are non-existent the appropriate analytical procedure can no longer be employed. The formulæ which are required to estimate missing values in the particular case where several isolated observations are missing have been given in papers now in press.[1, 2] The present paper is concerned with methods of analysing data derived from balanced incomplete block designs in which complete sets of experimental values are missing, i.e. a block or a treatment.

The notation introduced by Yates[6] will be followed as closely as possible. This notation, with slight modifications, has also been used by Fisher and Yates.[3]

The formulæ given below may all be derived by a straightforward application of the method of least squares.[4]

1. Missing Block.

(*a*) $k < \frac{1}{2}t$.

Without loss of generality it may be assumed that block 1, containing treatment 1, 2, ..., k, is missing. The set of constants which has to be determined is

mean : m.
blocks : $b_2, b_3, \ldots, b_b$; $S(b)=0$.
treatments : $t_1, t_2, \ldots, t_t$; $S(t)=0$.

If G is the grand total of existing observations and B and T stand for block and treatment totals, respectively, the normal equations are

$$(N-k)m-S(t_v) = G, \quad v=1, 2, \ldots, k.$$
$$k(b_u+m)+S(t) = B_u, \quad u=2, 3, \ldots, b.$$
$$(r-1)(t_v+m)+S(b)=T_v,$$
$$r(t_w+m)+S(b) = T_w, \quad w=k+1, \ldots, t.$$

In any b equation the summation is taken over the treatments contained in the block concerned and, in any t equation, it is taken over the existing blocks in which replicates of the treatments occur.

The equations are not independent but the solution is easily derived. Since treatments $k+1, \ldots, t$ are unaffected by the missing block the quantities $Q_{k+1}, Q_{k+2}, \ldots, Q_t$ retain their normal values, so that the corresponding t may be obtained directly from the relations

$$t_w = Q_w/krE.$$

The equations in $t_1, t_2, \ldots, t_k$ reduce to

$$Pt_1+t_2+ \ldots + t_k = Q'_1,$$
$$t_1+Pt_2+ \ldots + t_k = Q'_2,$$
$$\ldots \quad \ldots \ldots \ldots \ldots \ldots$$
$$t_1+t_2+ \ldots + Pt_k = Q'_k,$$

where $P=\{(k-1)(r-1)+\lambda\}$. The Q' are calculated in the ordinary manner except, of course, for the omission of the observations of the missing block. The solution of this set of equations is

$$t_v = AQ'_v+B(Q'_1+Q'_2+ \ldots + Q'_k),$$

where

$$A=(krE-1)/k^2rE(rE-1) \text{ and } B=-1/k^2rE(rE-1)$$

and Q'_v is omitted from the bracket on the right hand side.

This gives the complete set of values of the t. Direct substitution in the b equations yields the values of $b+m$ and the simplest method of determining m is by substitution of the t in the m equation.

The treatment comparisons, in terms of a single experimental unit, are given by the differences of the quantities t and the adjusted treatment means by $t+m$.

The reduction in the sum of squares due to fitting the constants b and t is

$$S B(b+m)+StT-G^2/N-k,$$

from which the sum of squares for testing the significance of treatments is obtained by deducting the sum of squares ascribable to blocks when treatments are disregarded, namely,

$$\frac{1}{k}S(B^2)-G^2/N-k.$$

(*b*) $k>\frac{1}{2}t$.

If $k>\frac{1}{2}t$ the following procedure is, arithmetically, the more convenient to use in practice. It is first necessary to calculate for each treatment a quantity, Q', defined as k times the treatment total plus the totals of blocks in which that treatment does *not* occur. The t of treatments not contained in the missing block are then given by

$$t_w=(Q'_w-G)/krE,$$

m by

$$m=\{G-S(t_w)\}/k(b-1)$$

and the t of treatments belonging to the missing block by the relations

$$t_v=\{Q'_v-k(b-1)m\}/k(rE-1).$$

Direct substitution in the b equations, which are now written in terms of the t of treatments not in the blocks, gives the values of $b+m$. In other respects the analysis follows the steps given in section 1 (*a*).

When a complete block of units is missing all treatment comparisons are not of the same accuracy. There are three types of comparison:

(i) between two treatments neither of which has a replicate in the missing block: variance $2\sigma^2/rE$,

(ii) between two treatments both of which have a replicate in the missing block: variance $\frac{2\sigma^2}{rE}\left(1+\frac{1}{rE-1}\right)$,

(iii) between two treatments one of which has a replicate in the missing block: variance $\frac{2\sigma^2}{rE}\left\{1+\frac{k-1}{2k(rE-1)}\right\}$.

Example.

Fisher and Yates[3] have given an example showing the analysis of an incomplete block experiment involving 9 treatments in 18 blocks of 4 units each. In this design $t=9$, $b=18$, $k=4$, $r=8$, $\lambda=3$ and $E=27/32$. The reader is referred to the book quoted for the original data.

The values of B and $b+m$ are given in Table 1, and in Table 2 are given the values of T, Q or Q' and the t.

TABLE 1.

B		20·7	19·8	11·8	32·1	33·0	20·7	17·8	11·5
$b+m$ ..		5·4992	4·8540	3·1843	8·0490	8·0167	5·0793	4·7623	2·9008
B	26·5	22·1	11·4	16·7	13·7	12·7	18·4	18·1	22·8
$b+m$ ..	6·6965	5·5417	2·5972	4·1499	3·1362	3·1738	4·7492	4·6210	5·4971

TABLE 2.

	Treatment.									
	1	2	3	4	5	6	7	8	9	
T	43·9	39·1	35·9	33·9	34·8	33·0	28·6	42·8	37·8	329·8
Q or Q' ..	23·4	0	−1·4	8·5	4·6	−5·4	−23·9	−1·3	−4·5	
t	0·8667	0	−0·0710	0·3594	0·1899	−0·2449	−0·8852	−0·0481	−0·1667	
$t+m$	5·72	4·85	4·78	5·21	5·04	4·61	3·97	4·81	4·69	

The normal equations are

$$68m-(t_3+t_4+t_5+t_6)=329\cdot8,$$
$$4(b_2+m)+t_2+t_6+t_7+t_9=\ 20\cdot7,$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$7(t_3+m)+b_3+b_5+b_8+b_{10}+b_{13}+b_{14}+b_{16}=\ 35\cdot9,$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$8(t_1+m)+b_3+b_6+b_{11}+b_{12}+b_{13}+b_{14}+b_{15}+b_{18}=\ 43\cdot9,$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

The quantities krE, A and B have, respectively, the values 27, 26/621 and −1/621, so that, for example,

$$t_1=23\cdot4/27=0\cdot8667$$

and

$$t_3=\frac{1}{621}\{26\times(-1\cdot4)-8\cdot5-4\cdot6+5\cdot4\}=-0\cdot0710.$$

Also

$$(b_2+m)=\frac{1}{4}(20\cdot7+0\cdot2449+0\cdot8852+0\cdot1667)=5\cdot4992,\ \text{etc.},$$

and, finally,

$$m=\frac{1}{68}(329\cdot8-0\cdot0710+0\cdot3594+0\cdot1899-0\cdot2449)=4\cdot8534.$$

The sum of squares attributable to the constants b and t is

$$5\cdot4992\times20\cdot7+\ldots+0\cdot8667\times43\cdot9-0\cdot0710\times35\cdot9+\ldots-329\cdot8^2/68$$
$$=1784\cdot7148,$$

while the sum of squares taken out by blocks alone is 173·2850. Table 3 shows the analysis of variance.

Examples of the three types of treatment comparison with their estimated standard deviations are

(i) t_1-t_2 $0\cdot87\pm0\cdot83$,
(ii) t_4-t_3 $0\cdot43\pm0\cdot90$,
(iii) t_1-t_3 $0\cdot94\pm0\cdot86$.

TABLE 3.
Analysis of Variance.

	Deg. Freed.	Sum. Sq.	Mean Sq.
Total	67	286·0100	
Residual	43	100·8252	2·3448
Constants b and t	24	185·1848	
Blocks	16	173·2850	
Remainder (treatment) ..	8	11·8998	1·4875

2. Missing Treatment.

In dealing with the case of a missing treatment it is convenient to consider the designs in which $\lambda=1$ separately from those in which $\lambda>1$.

(*A*) *Designs in which* $\lambda=1$.

Without loss of generality it may be assumed that treatment 1 is missing and that its first replicate occurs in block 1 together with treatments $2, 3, \ldots, k$ while its remaining replicates occur in blocks $2, 3, \ldots, r$.

The normal equations are

$$\begin{aligned}
(N-r)m-\mathrm{S}(b_u) &= G, \qquad u=1, 2, \ldots, r.\\
(k-1)(b_u+m)+\mathrm{S}(t) &= B_u,\\
k(b_v+m)+\mathrm{S}(t) &= B_v, \qquad v=r+1, \ldots, b.\\
r(t_w+m)+\mathrm{S}(b) &= T_w, \qquad w=2, 3, \ldots, t.
\end{aligned}$$

The equations in the t of the first block containing a replicate of the missing treatment reduce to

$$\begin{aligned}
tt_2+b_1+m &= Q'_2,\\
tt_3+b_1+m &= Q'_3,\\
&\cdots\cdots\cdots\cdots\\
tt_k+b_1+m &= Q'_k.
\end{aligned}$$

There are, in all, r such sets of equations involving r sets of the t, no two of which have a common t and, further, each set involves one of the first r values of the b.

The b_u+m are given by

$$b_u+m=\{tB_u-(Q'_i+Q'_j+\ldots)\}/(k-1)(t-1)$$

where Q'_i, Q'_j, ... are the Q' of treatments in block u, so that the values of the t are given by

$$t_w=\frac{1}{t}Q'_w-\left(B_u-\frac{1}{t}(Q'_i+Q'_j+\ldots+Q'_w)\right)/(k-1)(t-1)$$

assuming that treatment w also occurs in block u. The remaining $b+m$ can now be obtained by direct substitution of the t in the original equations of the blocks concerned and m is obtained by substitution in the m equation. The remaining steps proceed as in section 1.

There are two types of comparison:

(i) between two treatments which occur together in one of the r blocks containing the missing treatment: variance $\frac{2k}{t}\sigma^2$,

(ii) between two treatments which occur in different members of the set of r blocks containing the missing treatment: variance

$$\frac{2k}{t}\sigma^2\left\{1+\frac{1}{(k-1)(t-1)}\right\}.$$

It should be noted that the variance of the first type retains its normal value.

Any design in which $\lambda=1$, $b=t$ and $k=r$ may also be analysed by the method given below in section 2 (B).

(B) *Designs in which* $\lambda>1$.

(a) Designs in which $b=t$ and $k=r$.

These designs are symmetrical with respect to both the blocks and the treatments. Consider first the case $r<\frac{1}{2}t$.

The normal equations are

$$\begin{aligned}
(N-r)m-\mathrm{S}(b_u) &= G, \quad u=1, 2, \ldots, r.\\
(r-1)(b_u+m)+\mathrm{S}(t) &= B_u,\\
r(b_v+m)+\mathrm{S}(t) &= B_v, \quad v=r+1, \ldots, t.\\
r(t_w+m)+\mathrm{S}(b) &= T_w, \quad w=2, 3, \ldots, t.
\end{aligned}$$

The quantities Q or Q' are now calculated for the blocks instead of the treatments, the Q of any block being obtained by deducting from r times the block total, the totals of treatments occurring in the block. The b of blocks not containing the missing treatment are then given by

$$b_v=Q_v/r^2E$$

and the b of blocks containing the missing treatment by

$$b_u=AQ'_u+B(Q'_1+Q'_2+\ldots+Q'_r),$$

where A and B have their former values and Q'_u is omitted from the bracket on the right hand side. The values of the $(t+m)$ and m are then obtained by substitution.

When $\lambda=2$, there are, in general, two types of treatment comparison similar to those given for the case $\lambda=1$, with variances

$$\frac{r\sigma^2}{t}\left\{1+\frac{1}{r(2t-r)}\right\} \text{ and } \frac{r\sigma^2}{t}\left\{1+\frac{2}{r(2t-r)}\right\},$$

respectively. The first type only is possible when $t=4$ and $r=3$.

If $r>\frac{1}{2}t$, the values of the constants are best obtained by the method of section 1 (b), solving first for the block constants and subsequently determining the treatment constants by substitution. The following example illustrates the method.

TABLE 4.—*Square Roots of Scores.*

Block

1	2	3	4	5	6	7
(2) 0·0	(7) 2·4	(6) 2·4	(2) 3·6	(7) 4·7	(2) 5·1	(5) 7·5
(7) 2·2	(4) 2·6	(3) 2·4	(1) —	(6) 5·3	(4) 4·7	(1) —
(6) 3·3	(1) —	(4) 3·0	(6) 5·1	(5) 5·5	(5) 7·6	(7) 2·6
(3) 5·0	(2) 1·4	(1) —	(5) 6·5	(4) 6·6	(3) 9·6	(3) 4·4

Treatments are indicated by the numbers in parentheses; treatment 1 is missing.

TABLE 5.

Block

	1	2	3	4	5	6	7	
B	10·5	6·4	7·8	15·2	22·1	27·0	14·5	103·5
rB	42·0	25·6	31·2	60·8	88·4	108·0	58·0	
Q'	86·0	90·2	80·3	111·0	119·9	136·0	101·1	724·5
b	−1·2500	−1·1057	−2·0957	·9743	1·1714	2·3214	−0·0157	

Treatment

	2	3	4	5	6	7
T	10·1	21·4	16·9	27·1	16·1	11·9
$t+m$	2·2900	5·6100	4·1521	5·6621	4·3250	3·2750

In Table 4 are given data which have been taken from [6]. In this design $b=t=7$, $r=k=4$, $\lambda=2$ and $E=7/8$.

Table 5 summarizes the data required to calculate the constants and complete the analysis. The first step is to calculate the quantities Q' corresponding to the blocks. For example,

$$Q'_1=4B_1+T_4+T_5=42\cdot0+16\cdot9+27\cdot1=86\cdot0.$$

Next, the b of blocks not containing the missing treatment are evaluated; thus

$$b_1=(Q'_1-G)/r^2E=(86\cdot0-103\cdot5)/14=-1\cdot2500$$

and, using these, the value of $24m$ is

$$103\cdot5+1\cdot2500-1\cdot1714-2\cdot3214=101\cdot2572.$$

The remaining b may now be determined. For example,

$$b_2=\{Q'_2-r(t-1)m\}/r(rE-1)=(90\cdot2-101\cdot2572)/10=-1\cdot1057.$$

Finally, the $t+m$ are obtained by substituting the numerical values of the b in the t equations, thus

$$t_2+m=\frac{1}{4}(T_2+b_3+b_5+b_7)$$

$$=\frac{1}{4}(10\cdot1-2\cdot0957+1\cdot1714-0\cdot0157)$$

$$=2\cdot2900.$$

The residual sum of squares is 19·3264 with 12 degrees of freedom. Examples of the two types of treatment comparison with their estimated standard deviations are

(i) t_4-t_2 $\quad 1\cdot86\pm0\cdot97$,

(ii) t_3-t_2 $\quad 3\cdot32\pm0\cdot98$.

The generalized form of the variance of any treatment comparison is

$$\left\{\frac{2}{r}+\frac{2\alpha}{r^3E}\left(1+\frac{1}{rE-1}\right)+\frac{2\beta}{r^3E}\right\}\sigma^2$$

where $\alpha=\lambda-x$, $\beta=r-2\lambda+x$ and x is the number of times that pair of treatments occur together in the r blocks containing the missing treatment. For example, in the designs ($\lambda=3$) given by Fisher and Yates,[3] the numerical values of the factor within the brackets are

	Design		
x	(4.5.5.4)	(6.11.11.6)	(7.15.15.7)
1	—	328/891	268/855
2	6/11	326/891	—
3	—	—	14/45

(*b*) Designs in which $b\neq t$, $k\neq r$.

Owing to the asymmetrical relations of the blocks within the treatments, the solution of the normal equations is not as straightforward as in the above cases. The equations in the t are, however, easily reduced to the form

$$krEt_i+S(b+m)=Q'_i,$$

where the summation is taken over the blocks in which treatment i occurs with the missing treatment. If the members of this set of equations are multiplied by $(k-1)$ they can easily be expressed in terms of the t. After reduction to this form, the solution is best obtained in the manner given in [8]. The case, $k>\frac{1}{2}t$, is probably best dealt with in the same manner.

If exact values of the variances of treatment comparisons are required for special purposes they can be obtained by the method given in [8]. However, this procedure involves lengthy computations which will, in many cases, not be worth while. The exact variances given above may be used as a guide to the magnitude of the increases to be expected.

3. Youden Square.

This modification of the incomplete block design has been described in [9].

(*a*) *Missing block.*

In addition to the conditions stated in section 1 (*a*) it may be assumed that row 1 contains treatment 1, etc., so that, when $r<\frac{1}{2}t$, the normal equations are

$$\begin{aligned}
&r(t-1)m-S(t_v) &&= G, && v=1, 2, \ldots, r,\\
&r(b_u+m)+S(t) &&= B_u, && u=2, 3, \ldots, t,\\
&(r-1)(t_v+m)+S(b)-r_v &&= T_v,\\
&r(t_w+m)+S(b) &&= T_w, && w=r+1, \ldots, t,\\
&(t-1)(r_v+m)-t_v &&= R_v,
\end{aligned}$$

where the r_v, $S(r)=0$, are the constants representing the rows and R_v stands

for the total of existing values in the vth row. The solution of the equations is obtained by the method of section 1 (*a*) except for the determination of the r_v which are given by

$$r_v=\frac{rE-1}{rt(r-2)}\left[rR_v-G+\frac{1}{r(rE-1)}\{(r-1)Q'_v-(Q'_1+Q'_2+\ldots\ldots+Q'_r)\}\right],$$

omitting Q'_v from the second term in $\{\}$, and the t_v which are given by

$$t_v=AQ'_v+B(Q'_1+Q'_2+\ldots\ldots+Q'_r)+r(A-B)r_v,$$

where A and B have their former values.

If $r>\frac{1}{2}t$, the t_v are given by

$$t_v=\{(t-1)Q'_v+rR_v-rt(t-1)m\}/rt(r-2)$$

and the r_v+m by

$$r_v+m=(R_v+t_v)/t-1,$$

otherwise, the analysis proceeds in the manner given in section 1 (*b*).

(*b*) *Missing treatment.*

In these cases the solution of the normal equations is obtained by substituting the blocks for the treatments and following the method of section 3 (*a*).

In the Youden square the variance of any treatment comparison will be slightly greater than the variance of the corresponding comparison in incomplete blocks. There are, however, two exceptional cases. In both of these the variances have the values given above.

(i) Missing block; comparisons of type (i).

(ii) Missing treatment; comparisons between treatments which occur together λ times in the r blocks affected by the missing treatment. In this case $\alpha=0$.

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TECHNICAL NOTES

TOXICITY TESTS WITH THE QUEENSLAND FRUIT FLY, *STRUMETA* (*CHÆTODACUS*) *TRYONI* FROGGATT.

For a number of years, fruit fly control has involved the picking up and destruction of fallen and infested fruits and the trapping of adult flies, but in addition foliage poison sprays have been in general use. The regulations at present in force in New South Wales require either trapping or the use of foliage poison sprays, and the collection and destruction of all fallen and infested fruits at intervals not exceeding three days.

Early toxicity tests carried out by McCarthy[4] against Mediterranean flies (*Ceratitis capitata* Wied.) led to the adoption of a lead arsenate-molasses-fruit syrup mixture in New South Wales in 1931. A similar bait is still included in the latest regulations, but an alternative sodium fluosilicate-sugar bait was included in 1937. Sodium fluosilicate has been used in Western Australia against Mediterranean fruit fly, and laboratory tests carried out by Wright (unpublished) have shown this poison to be more efficient than lead arsenate and less injurious to the foliage. Wright also found sodium fluosilicate to be less effective when mixed with molasses. This conforms with the results of tests carried out by Ripley and Hepburn[9] in South Africa against the Natal fruit fly (*Ceratitis rosa* Karsch) and by Newman[8] in Western Australia against the Mediterranean fruit fly.

Methods of Testing.

During the past season, a further series of tests has been carried out in which certain factors operating in the original experiments have been varied. Queensland fruit flies die rapidly under cage conditions, unless a plentiful supply of water and food is available. Moreover, they need special requirements for breeding.[1] In some of the tests, previously referred to, the flies, following a period of starvation, were forced to feed on the poison spray in the absence of water in the cages. Enforced feeding under such conditions resulted in more rapid mortality ; and while the relative merits of the various poisons might not be changed no allowance was made for the possibility of any repellance, and the quick kill indicated would give a false impression of poisoning under field conditions.

Miller,[5] also working with the Mediterranean fly, stated that the treatment and previous feeding had great influence on the death of flies fed on insecticides, and that the longer the period from previous feeding, the more rapid was the kill.

Tests were carried out in small wooden cages having a sliding glass top and a fine wire gauze bottom. Corner supports raised this cage about $\frac{3}{4}$ inch from the bench. A continuous supply of water was provided by filling a wide-

mouthed bottle and inverting it over discs of blotting paper placed in Petri dishes.

In tests where an alternative food supply was continuously available, the bottles were filled with a 6·25 per cent. sugar solution and were inverted over blotting paper discs in the manner previously described.

Approximately equal amounts of the poison bait to be tested were sprayed on to the glass tops, allowed to dry, and the tops then slid into position on top of the various cages.

The flies used in the tests were bred out in the laboratory and confined in a single large cage with a plentiful supply of food and water until the beginning of the experiments. A random selection of flies, sufficient for the purposes of the various tests, was then made and the mortality noted at frequent intervals until the tests were concluded. The age of the flies at the beginning of the tests ranged from three to seven days.

Foliage Poison Sprays Tested.

The following materials were included in the tests :

(1) Tartar emetic plus sugar.
(2) Sodium fluosilicate plus sugar.
(3) Commercial sodium fluosilicate bait.
(4) Lead arsenate plus molasses.
(5) Phenothiazine plus sugar.
(6) Cryolite plus sugar.

In conformity with regulation requirements, lead arsenate was used at the rate of 4 ounces plus 4 pounds of molasses in 4 gallons of water. All other materials were used at the rate of 2 ounces of insecticide plus 2½ pounds of white sugar in 4 gallons of water.

Results of Toxicity Tests.

In Table 1 are recorded the results of the first series of experiments in which water only was placed in the bottles and feeding on the poison mixtures was enforced as an alternative to starvation.

TABLE 1.—*Results of Enforced Feeding on Poison Sprays.*

Poison Used.	No. of Tests.	Progressive Mortality of Flies after					No. of Flies in Test.
		1 day.	2 days.	3 days.	4 days.	5 days.	
1. Tartar emetic ..	3	36	**105**	115	117	133	141
2. Sodium fluosilicate	3	34	**85**	102	125	131	141
3. Lead arsenate ..	2		3	24	**49**	49	59
4. Cryolite	3	6	12	22	44	**96**	144
5. Phenothiazine ..	1						18
6. Check	3	1	2	4	4	17	96

Figures in bold type represent first record of a mortality of 50 per cent. or over.

The second series of experiments, in which sugar and water were available as an alternative food supply, are listed in Table 2.

TABLE 2.—*Results of Poison Spray Tests where an Alternative Food Supply was Available.*

Poison Used.	No. of Tests.	Progressive Mortality of Flies after										No. of Flies Tested.
		1 day.	2 days.	3 days.	4 days.	5 days.	6 days.	7 days.	8 days.	9 days.	10 days.	
1. Tartar emetic ..	5	52	**122**	148	154	162	164	169	170	177	179	206
2. Sodium fluosilicate ..	5	1	9	18	28	46	64	**79**	94	103	109	148
3. Commercial sodium fluosilicate bait	5		6	16	19	43	54	**101**	120	124	132	167
4. Lead arsenate	5	1	4	23	51	67	84	**99**	104	111	124	169
5. Cryolite.. ..	5			6	12	23	42	80	**93**	107	116	185
6. Check	5		1	2	2	2	2	4	6	9	16	145

Figures in bold type represent first record of a mortality of 50 per cent. or over.

Discussion of Results.

Consideration of the foregoing tables reveals that complete mortality was not obtained in any series and evaluation of the various treatments on this basis is not possible. Comparisons between mortalities at the end of the tests would depend on the survival of relatively few individuals, and it is now generally accepted that the basis for most accurate comparison of insecticides at equivalent concentrations would be the time taken to produce a 50 per cent. mortality.

In the case of enforced feeding it would then appear that tartar emetic and sodium fluosilicate are of approximately equal value and superior to lead arsenate and cryolite. Phenothiazine, an insecticide designed to replace lead arsenate for the control of codling moth, proved non toxic to flies under the conditions of this test.

The second series, which included an alternative food supply, presents a very different set of results. Tartar emetic proved to be much superior to all other sprays tested. Sodium fluosilicate and a commercially prepared sodium fluosilicate bait did not show to any better advantage than lead arsenate, and all three were little superior to the cryolite bait.

In view of the results obtained under conditions of enforced feeding, there seems to be some repellance or other factor which reduces the efficiency of sodium fluosilicate in the presence of an abundant alternative food supply. There is little falling off in efficiency in the tartar emetic-sugar bait under the same conditions. Tartar emetic produced a more conspicuous type of deposit which appeared to be hygroscopic and more attractive to flies. The chemical properties of tartar emetic do not indicate any hygroscopic characteristics.

It is of interest to record that a single test carried out with Mediterranean flies under the same conditions did not give this striking difference between

tartar emetic and sodium fluosilicate, and it would appear that this discrimination is confined to the Queensland species.

The periods required to give any large percentage of mortality may appear excessive, but laboratory tests have indicated that seven days elapse between the emergence of flies and first deposition of eggs. Under the conditions of the second test, flies were fully fed prior to exposure to the poison bait and an alternative food supply was also available. The percentage mortality at the end of six days varied from 79·6 per cent. in the case of tartar emetic to 22·7 per cent. in the case of cryolite.

Some allowance might also be necessary for the possibility of flies taking a sub-lethal dose and being unable to deposit eggs, or actually depositing sterile eggs.

Sprays Applied to Fruits.

In view of the use of lead arsenate and, more recently, cryolite for the control of other species of fruit flies in the United States of America[2] and the results obtained by the use of white oil-nicotine sulphate in New South Wales by Wright[10] a test was carried out with sprayed fruits placed in cages similar to the ones used in the toxicity tests.

The materials used in the experiment included lead arsenate, cryolite and white oil plus nicotine sulphate, but the results were not promising. All fruits became infested and a 50 per cent. mortality of flies was not obtained until 15 days from the beginning of the test with lead arsenate, and 18 days with the white oil plus nicotine sulphate.

White oil plus nicotine sulphate caused the collapse of a number of flies which subsequently recovered. One fly was suspended from the fruit by means of the partly inserted ovipositor and it finally fell to the floor of the cage and later recovered. Repeated sprayings of white oil plus nicotine sulphate might therefore be expected to give some partial protection, although this course is not advocated and would necessarily be confined to pome fruits.

Tartar Emetic.

Tartar emetic was developed as a fruit fly poison at Key West, Florida, for the eradication campaign against the West Indian fruit fly.[3, 7] It has also come into prominence lately as a spray for the control of various species of thrips, and is apparently more satisfactory for this purpose than the usual Paris Green-brown sugar mixture.[6] In these tests brown sugar and molasses were used without any resultant loss in toxicity, and this represents a decided advantage over sodium fluosilicate which must be mixed with white sugar only. In addition, sodium fluosilicate is not as readily soluble in water as tartar emetic and special precautions are necessary in preparing the bait.

Preliminary tests on apples and peaches have shown that foliage injury is no more severe in the case of tartar emetic than with sodium fluosilicate.

Both tartar emetic and sodium fluosilicate are superior in this respect to the lead arsenate-molasses mixture.

S. L. Allman.

Dept. Agriculture,
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TRANSMISSION OF INFECTIOUS CHLOROSIS OR HEART-ROT OF THE BANANA AND ITS RELATIONSHIP TO CUCUMBER MOSAIC.

Infectious chlorosis(4) was first recorded in New South Wales in 1929, and during the past decade a number of sporadic outbreaks of the disease has occurred. In some years individual growers in the Richmond River district have experienced substantial losses, when several hundreds of plants have succumbed to the disease during the first year of the establishment of their plantations. This has entailed extensive " refilling " and, in some instances, the abandonment of portions of plantations. Outbreaks of infectious chlorosis are observed mainly during May, June and July, in plants which have been set out the previous year. The chlorotic stage may or may not be accompanied by rotting of the heart-leaf and central cylinder, depending on prevailing weather conditions. Plants which do not develop a heart-rot enter the mosaic stage and may show this symptom throughout the following spring and summer. The growth of affected plants is retarded, and while bunches are sometimes formed they are small and unmarketable. Following the initial outbreak, natural spread of the disease within a plantation either does not occur or is insignificant.

Transmission.

Transmission of infectious chlorosis by the aphid *Pentalonia nigronervosa* Coq.* was demonstrated in 1930.(2) Further studies have shown that the virus

* All aphids were identified or checked by Mr. E. H. Zeck, Entomologist, N.S.W. Dept. of Agriculture.

may be transmitted also by *Macrosiphum gei* Koch., *Aphis gossypii* Glover and by an unidentified species of the genus *Aphis*. Transmission by *Pentalonia nigronervosa* has been confirmed only with difficulty, and this species is regarded as a capricious vector that is unlikely to be of importance under natural conditions.

Attempts to transmit the virus by mechanical inoculation within the Cavendish banana and within a seeded *Musa* (species undetermined) have so far been unsuccessful.

Using *Aphis gossypii* as the vector, the virus has been transmitted from the Cavendish banana to *Musa ensete* Gmel., and to the abovementioned seeded *Musa* sp. From the latter species the virus has been transmitted by *A. gossypii* to the Cavendish and Gros Michel varieties of banana, to abaca (*M. textilis* Nee), to canna (*Canna indica* L.), to cucumber (*Cucumis sativus* L.), to squash (*Cucurbita maxima* Duchesne) and to tomato (*Lycopersicum esculentum* Mill.).

From cucumber and squash the virus has been transmitted readily by mechanical inoculation to cucumber, squash and tobacco ; and from tobacco, to cucumber, squash and the seeded *Musa* sp.

The symptoms caused by the virus in tobacco are typical of those caused by *Cucumis Virus I*, with which the writer is familiar from work with this virus

Fig. 1.—Mosaic stage of Infectious Chlorosis in a Cavendish sucker propagated from a naturally-infected stool.

at the University of Wisconsin. Symptoms in cucumber and squash also conform with those of *Cucumis Virus I* in these hosts, while the "fern-leaf" symptom is a prominent feature when the virus is transmitted by *A. gossypii* to tomato. It is the writer's opinion that the virus under consideration is a strain of *Cucumis Virus I*.

A number of random collections from different parts of New South Wales of cucumber, squash, tomato and silver beet foliage, displaying symptoms of mosaic, have been tested by inoculation of young seedlings of the above-mentioned seeded *Musa* sp. In all cases symptoms identical with those caused by the infectious chlorosis virus have been obtained.

Interpretation.

Interpretation of the incidence of infectious chlorosis of the banana in the field may now be possible. It is considered that outbreaks of the disease are likely to be experienced only in areas where vegetable crops (cucurbits, tomatoes) are interplanted with or grown in close proximity to bananas during the early

Figure 2.

Primary lesions with associated necrosis on "first-symptom" leaf of Gros Michel banana infected in glass-house by *Aphis gossypii*.

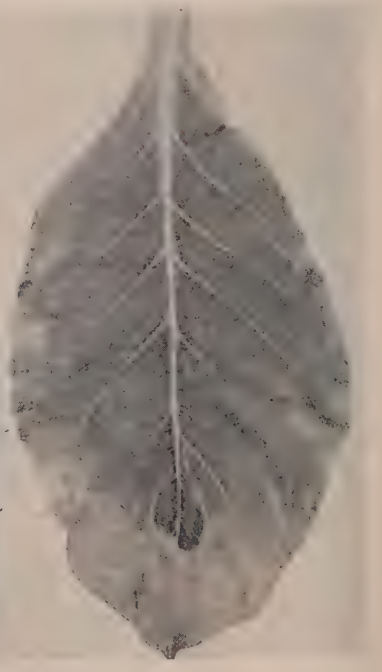

Figure 3.

Mild mosaic symptom in tobacco caused by "Infectious Chlorosis" virus.

stages of the establishment of a plantation. *Cucumis Virus I* is apparently not endemic in any of the regions in New South Wales where banana-farming is undertaken. Outbreaks of infectious chlorosis have always been localized to individual plantations or groups of plantations, and, in the case of large plantations, to those portions in which vegetable crops have been grown. Infectious chlorosis has been of more frequent occurrence in the Richmond River district than in other banana areas, and it is noteworthy that it is the practice of many growers in this area to interplant cucurbits, beans, potatoes, tomatoes, etc., among young bananas.

Common plantation weeds may become infected during an outbreak of infectious chlorosis. Specimens of the following plants with mosaic or similar symptoms have been collected in a portion of a plantation in which infectious chlorosis was spreading: *Solanum nigrum* L., *S. verbascifolium* L., *S. seaforthianum* Andr., *Phytolacca octandra* L., *Homalanthus populiflius* Grah., *Passiflora alba* Link and Otto, *Physalis peruviana* L., and *Bryanopsis laciniosa* Naud. These diseased weeds occurred under circumstances which made it highly probable that a single virus was involved, and the identity of the virus was demonstrated in the case of the interplanted crop of Marglobe tomato plants, showing " fern-leaf " mosaic, in which the weeds were collected.

Accepting the identity of *Cucumis Virus I* and Wellman's *Celery Virus I*, the symptoms described by Wellman[5] for *Musa sapientum* would be those of infectious chlororis. This view is supported by published figures. It is also probable on the basis of symptoms and vectors that the mosaic disease of abaca in the Philippines[1, 3] is caused by *Cucumis Virus I*. Cavendish banana plants affected with infectious chlorosis are quite susceptible to the banana bunchy top virus,[4] indicating that the latter belongs to a different immunological group from that under discussion.

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ON THE OCCURRENCE OF *CERCOSPORELLA HERPOTRICHIOIDES* FRON IN SOUTH AUSTRALIA.

A feature of the European literature dealing with foot rot diseases of wheat during the last decade has been the frequency of reference to the disease caused by *Cercosporella herpotrichioides* Fron.[1]* This fungus has now been found for the first time on wheat grown in South Australia.

Figure 1.
"Eyespot" lodging in a wheat crop.

The disease which this fungus causes has been given a variety of names. For the sake of uniformity it is suggested that the name " eyespot lodging ", which is descriptive, distinctive and has British approval,[2] should be adopted in Australia.

The occurrence of " eyespot lodging " was first suspected in November, 1937, on wheat growing in experimental plots at the Waite Agricultural Research Institute, Glen Osmond, South Australia. The area on which the disease was first noticed had grown five wheat crops in succession. The wheat at the time was still green, but approaching maturity. Small areas of crop appeared as if they had been trampled on by stock (Fig. 1). Isolations of fungi from the

* The specific name *herpotrichoides* is very commonly used for this fungus, but there appears to be no valid reason for changing the name originally proposed by Fron.

diseased bases were made, but none of the variety of forms secured agreed in cultural characteristics with those described for *C. herpotrichioides* Fron.[3] [4]

A similar disease was observed in the following year on wheat growing on the same land. The wheat when first examined was in the jointing stage, and on the base of the stems unilaterally placed eyespot lesions were well developed. Microscopic examination of these lesions revealed the presence of small, dark stromatic masses of irregularly shaped cells and the presence of the long, obclavate, slightly curved, and up to seven septate, spores of the dimensions described for *C. herpotrichioides.*[1] At the same time isolations were made from the diseased tissues on to potato dextrose agar, and slow-growing, compact, velvety, grey, hemispherical colonies developed readily and consistently. Subcultures of this fungus on potato dextrose agar were placed in the shade out of doors (minimum temp. *c.* 40° F.), and when examined later small numbers of spores similar to those found on the diseased plants were found. These spores germinated readily in tap and distilled water.

A comparison of the local isolations with isolates from France and England has also been made.* The cultures have all the same general characteristic

Figure 2.
"Eyespot" lodging lesions on the bases of wheat plants.

* I am indebted to Dr. Et. Foëx, Versailles, and Miss Glynne, Rothamsted, for the exchange of cultures which has made these comparisons possible.

appearance. Slight differences in colour and in the rate of development of colonies existed between the different isolates, but these are considered to be of minor importance. Actually the French isolates of the same fungus varied more in appearance among themselves than did the South Australian fungus from the English and some of the French isolates. For fuller descriptions of the fungus the reader is referred to papers by Sprague[3] and Foëx and Rosella.[4] Inoculation experiments utilising the fungus developed on a barley hull material are now in progress, but to secure adequate proof of pathogenicity it may be necessary to use the fungus grown on cornmeal on which, with suitable conditions, Sprague claims it sporulates freely.

Symptoms of "Eyespot Lodging" Disease.

The main features of this disease as it affects individual plants are illustrated in Fig. 2, and its effects on a wheat crop in Fig. 1. For fuller details of description the reader should refer to the papers already cited.

The disease progresses quite slowly—well-developed basal lesions can be observed in South Australia in early September long before any lodging occurs. Lodging is by no means an invariable sequel. Many plants may develop eyespot lesions, remain standing and yield well. Thus in 1938, although lesions were observed on a large number of plants, there was only a small amount of lodging. When lodging occurs its appearance is quite distinctive. The stalks bend sharply near ground level and the straws criss-cross in all directions. The appearance of a diseased patch at this time emphasises the aptness of the French name for the disease "Le Piétin verse"; "L'aspect . . . est sensiblement celui qu'il aurait s'il avait piétiné par les moutons".[4]

Relation of Disease to Soil Type and other Factors.

Development of "eyespot lodging" in relation to environmental factors has received much attention, both in France and the United States, and in considering the likely distribution and possible future importance of this disease in Australia Sprague's work[5] calls for special reference.

The soil at the Waite Institute is a typical red-brown earth[6]; it contains a fairly high proportion of fine sand and silt, and the field in which the disease occurred holds moisture at the soil surface when wet and has a tendency to set hard when dry. The average annual rainfall is 23·7 inches. "Eyespot lodging" was also observed this year on wheat at Roseworthy Agricultural College (average annual rainfall 17·3 inches). In view of Sprague's work, it appears likely that in this case a better than average winter rainfall may have contributed to this development.

The circumstances of the occurrence of "eyespot lodging" in South Australia afford no ground for the suggestion that the disease has been newly introduced. In view of the economic importance of this disease abroad

and the desirability of securing knowledge on its local distribution, fellow workers are asked to keep a look out for this disease, especially in crops where lodging occurs.

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OCCURRENCE OF *SCLEROTINIA MINOR* JAGGER ON A BOWLING GREEN.

Sclerotinia minor was differentiated from *S. sclerotiorum* (Lib.) Mass. (formerly *S. libertiana*) by Jagger(1) on grounds which included the smaller size of its apothecia and sclerotia. Cunningham(2) questioned the right of *S. minor* to specific rank, but most authors appear to have accepted it as a valid species.(3) As far as the writer knows, this species (as distinct from *S. sclerotiorum*) has not yet been recorded in New South Wales. A fungus agreeing in most respects with *S. minor* was recently observed on a bowling green in Canberra, A.C.T.

This green is infested with " water-weed " (*Hydrocotyle* sp.), a low-growing, small-leaved perennial which spreads freely by runners rooting at the nodes. It has almost suppressed the grass in many patches up to several square yards in area. When closely cut, it forms a turf which is normally quite satisfactory for bowling. The water-weed foliage is subject to a fungal disease, which is most prevalent during mild weather with moderate air and soil temperatures (about 60° to 75° F.). It is specially favoured by heavy dews. These conditions are most common in spring and autumn. The individual affected patches usually are not more than about nine inches in diameter, though areas of several square feet may become diseased owing to the coalescence of smaller patches.

In each patch the attack usually spreads from a centre of infection. The advancing margin is irregular in outline and under humid conditions is bounded by a zone about 1 cm. wide, formed by the abundant aerial hyphæ of the fungus, shading from greyish white on the edge of the affected area to buff further in. For a centimetre or more within this zone, the soil is covered with a light brown slimy film formed by the collapsed leaves and fungal hyphæ. Under favourable conditions black sclerotia, about 1 mm. in diameter, may be formed as the film dries out. In the centre of each affected area there is at first a regrowth of grass which is later suppressed by the water-weed. The fungus

Dimensions and Variability of Ascospores and Asci of Sclerotinia *Species.*
(All measurements in microns.)

Fungus.	Author.	Material.	No. Measured.	Range.		Length.			Breadth.		
				Length.	Breadth.	Mean.	S.E.	S.D.	Mean.	S.E.	S.D.
S. minor (Canberra)	W.V.L.	Ascospores.	100	6·2–19·7	6·2–12·3	14·26	0·236	2·36	7·79	0·154	1·54
S. minor ..	M. A. Keay.	Ascospores.	100	10–18·5	5·5–10	14·1	0·129	1·295	7·89	0·083	0·827
S. sclerotiorum ..	M. A. Keay.	Ascospores.	100	10–16	4·5–8·5	12·86	0·118	1·177	6·64	0·087	0·875
S. minor (Canberra)	W.V.L.	Asci.	50	127–171	8·01–12·9	152·8	1·542	10·907	11·6	0·166	1·171
S. minor ..	M. A. Keay.	Asci.	93	130–180	8–14·5	150·1	1·06	10·57	12·0	0·16	1·6
S. sclerotiorum ..	M. A. Keay.	Asci.	75	108–150	8·8–14·6	122·6	0·91	9·13	11·7	0·14	1·4

appears to have little effect on grass, and it does not kill the runners of the water-weed; only the tender foliage of the latter is vigorously attacked. The fungus often advances faster in one direction than in others, giving the majority of the patches a somewhat horseshoe-shaped outline.

The uneven surface caused by the disease seriously affects the playing quality of the green. The standard treatments with mercuric chloride alone or mercuric chloride plus mercurous chloride[4] give temporary control, but they need to be applied as a preventive a week or so before an outbreak is expected, and must be repeated at intervals of two or three weeks if conditions remain favourable for the recurrence of disease. Treatments with lime-sulphur or malachite green have no appreciable effect.

On agar media, the fungus isolated from the diseased turf forms abundant small black sclerotia, 0·5 to 2 mm. in diameter, as described by Jagger for *S. minor*. These are smaller than the typical sclerotia of *S. sclerotiorum*. Sometimes the sclerotia coalesce to form a crust 1 cm. or more in length. The optimum temperature for growth on potato dextrose agar is 20° C. The writer's attempts to germinate the sclerotia in damp sand were not successful up to the time of writing, but Dr. W. L. Waterhouse, of Sydney University, germinated sclerotia from a culture supplied by the writer, in the following way. The sclerotia (from a P.D.A. culture two months old) were placed on wet cotton-wool in a Petri dish and kept thoroughly moistened in the laboratory. The first sign of germination was observed after about three months, and the first apothecium four weeks later. Dr. Waterhouse kindly offered this apothecial material to the writer for determination.

In the accompanying table, the writer's measurements of asci and ascospores are compared with certain of those recorded by Keay[3] for *S. minor* and *S. sclerotiorum*. It will be seen that there is good agreement between the means for the two sets of measurements of *S. minor*, both of which differ from those of *S. sclerotiorum*, especially with regard to the length of asci. The apothecia agreed with those described for *S. minor*, except that they remained cup-shaped instead of forming a flat or slightly convex disk at maturity. The writer's measurements were restricted to mature asci and ascospores, as specified by Keay.[3] Hyaline globose microconidia, 3 to 4 μ in diameter, developed abundantly on the surface of the upper quarter of the stalks of some of the apothecia, giving them a frosted appearance.

The writer gratefully acknowledges his indebtedness to Dr. W. L. Waterhouse for the supply of named cultures of various *Sclerotinia* and *Sclerotium* species, in addition to the apothecial material mentioned above.

C.S.I.R., W. V. Ludbrook.
Canberra, A.C.T.

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EFFECT OF MANGANESE ON POWDERY MILDEW OF WHEAT.

During 1939, wheat grown in quartz sand in pots under glasshouse conditions at the Waite Institute was subjected to treatment with four levels of manganese as one variant in the experiment. Under the prevailing conditions of growth, powdery mildew (*Erysiphe graminis* DC) developed very freely. However, differences in the intensity of infection in adjacent pots were so marked that a detailed examination of all plants was undertaken.

The supply of potash,[2, 7, 8, 9] cadmium,[6] lithium[7] and silica[1, 4] to growing plants has been reported to reduce the susceptibility of wheat to powdery mildew, while lead[7] and zinc[7] apparently have little effect. On the other hand, with nitrogen[3, 7, 8] and phosphorus,[5, 8] the incidence of powdery mildew tends to increase as the supply of these nutrients is increased from minimal amounts. So far as the author is aware, no relationship between manganese supply and powdery mildew has been noted. Hence, the following observations are worth recording.

Each pot, of which there were ten for each level of manganese, had six wheat plants (var. Ranee 4H) eleven weeks old at the time of inspection, the plants being very uniform as regards size and number of leaves. An arbitrary scale of disease rating was adopted with a range from 0 for plants free from infection, to 5 for those severely diseased. Each plant was examined and allotted a figure to show the degree of infection. Analysis of the data obtained gave the results set out in the accompanying table.

Rate of Dressing of $MnSO_4$ in lbs./ac.	Disease Rating. (Mean of 60 plants.)	Standard Error.
0	3·37	
16	3·12	±0·08
32	2·83	
264	1·45	

It will be observed that each addition of manganese sulphate significantly reduced the infection below that of the preceding smaller dressing.

T. T. Colquhoun.

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The Australian Institute of Agricultural Science

MEETINGS OF COUNCIL

December, 1939, Meeting.

Held at Dept. of Agriculture, Melbourne, on December 7th, 1939, at 5.15 p.m. *Present :* Mr. W. B. Miller (V.) (in chair), Dr. A. E. V. Richardson (S.A.), Dr. H. C. Forster (W.A.). Mr. G. W. Leeper (A.C.T.), Mr. H. J. Geddes (T.), Mr. J. L. Gillespie (N.S.W.), the Hon. Treasurer (Mr. R. L. Twentyman) and the Hon. Secretary (Mr. A. J. Vasey). Apologies were received from Mr. P. S. Lang (Q.) and the Asst. Hon. Secretary (Mr. R. D. Croll).

The Secretary reported the receipt of a letter from Dr. Sutton (W.A.) concurring under the circumstances in the grant of £11 16s. to the Victorian Branch for the purchase of maps for population and potentialities survey. This grant was then passed by the meeting.

The following were admitted to corporate membership : F. F. Filan (N.S.W.), J. M. Harvey (N.S.W.), S. C. Graham (N.S.W.).

A letter was received from the Hon. Secretary of the Australian National Research Council, through the Hon. Secretary of N.S.W. Branch, urging that the Institute as a professional organisation should keep in close touch with the Research Council as a central co-ordinating body for the war effort of scientific societies.

The financial statement showed a balance at bank of £210 1s. 11d. as at December 7th, 1939.

The meeting closed at 7.25 p.m.

January, 1940, Meeting.

Held at Dept. of Agriculture, Melbourne, on January 25th, 1940, at 5.10 p.m. *Present :* Mr. W. B. Miller (V.) (in chair), Dr. A. E. V. Richardson (S.A.), Dr. H. C. Forster (W.A.), Mr. G. W. Leeper (A.C.T.), Mr. H. J. Geddes (T.), Mr. J. L. Gillespie (N.S.W.), the Hon. Secretary (Mr. A. J. Vasey) and the Assistant Hon. Secretary (Mr. R. D. Croll). Apologies were received from the Hon. Treasurer (Mr. R. L. Twentyman) and Mr. P. S. Lang (Q.).

The payment of per capita grants to the Branches, at the previous rate of 5s. 6d. per financial corporate member, in respect of the year 1939, was approved.

Mr. P. N. Forte (W.A.) was elected to corporate membership. Messrs. T. Gould, R. W. Clarke and A. C. Sundstrom (N.S.W.) were elected to student membership.

The following resolution, a decision on which will be taken at the February meeting of Council, was drafted : " That members of the Institute on active service at home or abroad be relieved of the responsibility for paying their subscriptions to the end of the financial year in which they are discharged from such service, and that during this time they shall be entitled to all the privileges of full membership. Active service in this connection shall be defined as *full-time service* at home or abroad in military, naval or air force activities."

A letter was received from the Secretary, Dept. of the Interior, Canberra, acknowledging receipt of the Hon. Secretary's letter regarding the population potentialities survey and inquiring if it would be possible for the information collected to be made available to the Department of the Interior, where it may be of great interest in connection with the government's immigration policy. The Hon. Secretary to reply that the Institute would be pleased to do so when the information was sufficiently complete.

The financial statement showed a balance at bank of £219 9s. 11d. as at January 24th, 1940.

The Council desired to direct the attention of secretaries and treasurers in regard to their responsibilities for recommendations in regard to the termination of the membership of members who were more than two years in arrears, and for advising the Business Manager of the Journal regarding cessation of issue of the Journal to those who had not paid a subscription for the year 1939.

The meeting closed at 7.10 p.m.

THIRD GENERAL MEETING

The Third General Meeting of the Institute will be held in Adelaide during August. This will precede the meetings of the Australian and New Zealand Association for the Advancement of Science in the same city. Full particulars will be announced later.

MEETINGS OF BRANCHES

New South Wales Branch.

The fifth annual general meeting was held at Science House, Sydney, on February 9th.

The following office-bearers were elected for 1940: President, Mr. A. W. S. Moodie; Vice-President, Mr. E. Breakwell; Hon. Secretary, Mr. H. P. Brown; Hon. Treasurer, Mr. L. Wilson; Committee, Messrs. E. T. Edwards, C. J. Magee and P. A. Reid.

The retiring President (Mr. E. Breakwell) delivered his presidential address, the subject being "Agricultural Education, Research and Extension in New South Wales". A summary of this address is published in this issue of the Journal.

Victorian Branch.

In the joint campaign in connection with the problem of soil erosion in Victoria, sub-committees from the Victorian Institute of Surveyors, the Institute of Engineers and the A.I.A.S. have been formed and certain proposals considered. These will be submitted later as a joint recommendation as to the action which it is considered should be undertaken by the State Government.

A series of technical lectures was delivered over a period of five weeks. In these, the technical aspects of the problem and its control were presented. In addition, it is intended to publish the lectures in handbook form. A publicity committee has also been formed for the purposes of enlightening the general public on this question.

South Australian Branch.

A general meeting held on 23rd November, 1939, was addressed by Mr. C. G. F. Johnson, Engineer for Water Supply, on the subject of the Water Supplies of South Australia. The low natural rainfall over large sections of the country, the limited catchment areas and the need for long pipe lines combined to make the provision of an adequate country water supply a large and expensive undertaking. Mr. Johnson then went on to describe and illustrate with photographs the problems encountered in each of the four regions into which the settled parts of the State were divided for water supply purposes.

Queensland Branch.

Dr. D. A. Herbert and Mr. J. H. Smith gave short addresses at the meeting held on 2nd November, 1939. Dr. Herbert described recent advances in plant physiology, centring

round the problems of fruit storage where the aim is to retard natural ripening and maintain freshness without injuring the fruit. Such problems must take into account the anatomy, the cell physiology and the history of the fruit. There are five outstanding features of the physiology of a fruit, comprising evolution of carbon dioxide, absorption of oxygen, emission of heat, evolution of water vapour and evolution of small quantities of esters and ethylene Low temperatures flatten the senescence respiration curve and prolong storage life. At the lower temperatures suitable for apple storage, tropical fruits are superficially blemished, are susceptible to fungal invasion and fail to ripen. In general they are stored between 40 deg. and 50 deg. Increase of carbon dioxide in the storage atmosphere slows down respiration and lengthens the storage life of fruit. Gas storage is usually applied with low temperatures. The whole matter of gas concentration is exceedingly complex and it appears that the atmosphere of the intercellular spaces is more important than that of the store. The effects of the exhalations of esters and ethylene on fruit in storage were discussed.

Mr. J. H. Smith, in speaking of some recent developments in entomology, dealt with three separate matters : codling moth control in Queensland, the conception of " outbreak centres " in grasshopper infestation, and the use of derris as an insecticide. In Queensland there has been a movement from arsenical sprays for codling moth to the white oil-nicotine sulphate combination. The alternate sprays are, however, no more effective than arsenate of lead and further improvements are expected from varied methods of application. Victorian studies led to two conclusions : (*a*) codling moth is active in spurts throughout the year ; (*b*) egg laying occurs mainly during these spurts. The problem then is to discover when the spurts occur and to spray them. Determinations of moth populations on the wing have been made in Queensland, using series of moth lure pots containing a cheap diluted wine.

The term " outbreak centre " has recently been used by Dr. Key in connection with grasshopper investigations. The theory is that, normally, the plague grasshopper is confined to certain parts of Australia and, depending on the conditions in these areas, outbreaks may spread elsewhere. Population density in the outbreak centre is brought about by synchronised egg-hatching. Density of population leads to migration. The reversion to the outbreak centre stage is a natural phenomenon. In Africa, where the micro-climate and outbreak centres have been defined with precision, the principle of preventing the spread of grasshoppers from outbreak centres is being applied.

On 5th December, Mr. P. J. Skerman gave an illustrated lecture on recent advances in farm machinery, and Mr. A. F. Bell showed a film of cane harvesting machinery in operation.

Tasmanian Branch.

The fifth annual general meeting was held on December 1st, 1939. The annual report and balance sheet for 1939 was read and adopted.

Election of office-bearers for 1940 resulted as follows : President and Federal Council Representative, Mr. R. A. Sherwin ; Vice-President, Dr. J. W. Evans ; Secretary-Treasurer, Mr. H. R. Dickinson ; Committee Members, Mr. H. V. Rees and Mr. J. T. Gemmell ; Sub-Editor, Mr. C. L. Goldstone ; Auditor, Mr. J. O. Henrick.

The retiring President (Dr. J. W. Evans) gave a brief address. He drew a comparison between the small number of members in Tasmania compared with the others, and stressed the need for the full cooperation of all members. He pointed out that some meetings had been poorly attended and added that members should place more importance on the activities of the Institute which was destined to play an important part in the agricultural life and policy of Australia.

Dr. Evans said that the Committee might consider the three types of meeting held in other States : (i) semi public meeting, (ii) exhibits, (iii) luncheons to distinguished visitors.

Also more attention might be given to Press publicity.

Western Australian Branch.

A general meeting of the Branch was held on December 15th, when a Branch constitution was discussed and adopted. At the same meeting, Mr. R. P. Roberts exhibited 33 mm. film strips and 16 mm. films such as are largely used by the United States Department of Agriculture in its extension services. These films have been purchased by the Institute of Agriculture, University of W.A.

Current Notes and News

Irrigation Research Station, Griffith.

Extensions to the laboratory at the Irrigation Research Station, Griffith, N.S.W., which are shown in the accompanying photograph, were opened by Mr. H. R. Nock, M.P. on October 3rd, 1939.

The work of the Station falls into three main groups : (1) Studies of the soil from the point of view of the irrigationist (soil water relationship, application of water to soil, soil structure and texture) ; (2) studies of plant nutrition with reference to minerals and organic fertilising materials ; (3) studies of the stock and scion, and shoot and root growth of citrus trees.

As a basis for this work, permanent field experiments have been established which include an inorganic fertiliser trial, a green manurial trial, and tile drain and other soil treatment experiments.

The buildings of the Station accommodate a number of laboratories. The soils laboratory is used for work of a bulky or dusty nature, such as the preparation of soil monoliths, or of pots for pot cultures and washing apparatus. The Kjeldahl apparatus is also installed in this room. The biological laboratory is used mainly for botanical work. Hydrogen ion determinations, electrolytic conductivity, photomicrography, and other work where the absence of dust and acid fumes is desirable, is carried out in the physical laboratory. The drawing office is provided with a bench and conveniences for drawing.

It is also fitted as a photographic studio for taking photographs of pots, specimens, etc. Though small, the dark room is well fitted with light tight drawers, drying cabinet, developing bench, enlarger, etc.

A vacuum system is installed in the physical and soils laboratories, and these two rooms are serviced with petrol vapour gas. Rock gas (iso-butane) is installed in the chemical and biological laboratories. The biological and chemical laboratories, dark room and glass house are supplied with rain water in addition to the main water supply from the irrigation canal.

A soils display is arranged in the vestibule. A wall diagram and relief model of the irrigation areas illustrate the relation of the main soil types to the topography and recent geological changes. A series of soil monoliths and soil maps of the area further illustrate these features. This display is of value for reference, and, besides being of value to the investigator, is the subject of keen interest to the practical irrigationist.

Outbuildings directly concerned with the laboratory investigations include a glass-house, soils preparation shed and still room, and a hydraulics laboratory. The hydraulics laboratory is used for the calibration of instruments and gauges used in the control and measurement of water, in connection with irrigation investigations.

Lectures on Soil Erosion.

The question of soil erosion has been receiving active attention in Victoria, and a series of technical lectures was arranged in Melbourne by the Victorian Institute of Surveyors. These were given on successive Friday evenings in the Kelvin Hall, Collins Place, commencing February 2nd, when the subjects treated were Definition of Soil Erosion (Dr. H. C. Forster and Mr. C. T. Clark) ; The Geological Factors (Mr. W. Baragwanath) ; and The Physiographical Factors (Dr. E. S. Hills).

On February 9th, Mr. H. G. Strom dealt with Hydraulic Principles, Mr. C. T. Clark with Insidious Sheet Erosion, and Mr. J. Brake with Pasture Improvement as a Cure.

On February 16th, Sand Drift was the subject of Mr. R. F. McNab's address. On this occasion also, Mr. H. L. Hore dealt with Experimental Research in Sand Drift, and Mr. H. G. Strom with Headward Erosion, Gullying and Control.

On February 23rd Mr. G. T. Thompson spoke on Stream Erosion, Siltation and Control. Mr. W. J. Lakeland gave an address on Forests as a Control Factor.

On March 1st Mr. A. A. Hone will speak on Forestry on the Farm, and Dr. H. C. Forster on Land Husbandry as a Control Factor.

Imperial Mycological Institute.

Members of the A.I.A.S. will be pleased to know that the Executive Council of the Imperial Mycological Institute has planned to do all possible to retain the staff of the Institute during the war period, and to publish the *Review of Applied Mycology* regularly each month. Plant pathologists everywhere would feel the loss of this valuable publication should it be stopped or much curtailed, and it is gratifying to know that departure from present procedure is unlikely. Some of the literature usually abstracted, however, will naturally not be avialable while the war lasts.

Mr. S. F. Ashly, Director of the Institute, wrote last year in reference to the cancellation of the Fourth Imperial Mycological Conference, and expressed cordial appreciation of the contributions offered by members of the A.I.A.S. for the Conference.

Corrigendum.

Mr. J. Harold Smith, of Queensland, writes as follows :

In my article on Insects and Their Influence on Agricultural Development (this *Journal*, September, 1939) I stated that in Western Australia " the Mediterranean fruit

fly . . . attacks, not only the known host fruits but others such as grapes and tomatoes." My reference to the tomato as a host was based on information which cannot now be rechecked. Mr. C. F. H. Jenkins, Government Entomologist in that State, however, informs me that he has no such host record and I naturally accept Mr. Jenkins' statement that there has been no authentic record of tomatoes having been infested by fruit fly in Western Australia.

Book Review

THE GERMAN FAT PLAN AND ITS ECONOMIC SETTING, by KARL BRANDT.

(*Pp.* 344, *with* 39 *tables*, 29 *charts, bibliography and index. Published by the Food Research Institute, Stanford University, California,* 1938. *Price* 3 *dollars net.*)

This book is the sixth of a series dealing with the world-wide production, distribution and consumption of fats and oils. The author, who is at present Professor of Agricultural Economics at the Food Research Institute, Stanford University, was formerly a Professor of the Agricultural High School and Director of the Institute of Agricultural Marketing at Berlin.

As the title suggests, the work is mainly an analysis of the whole economy of fats and oils under the present German régime. Its scope and significance, however, are not confined to this one aspect. The economic, and, to a large extent, political background of the German fat plan is exhaustively treated and its development from post war (1914-18) origins is clearly traced.

The book has lessons for the agricultural student, other than those pertaining to governmental control of production and marketing. Viewed against a background of ever increasing world competition between dairy and animal fats, and vegetable and marine oils, the German fat plan of today emphasises the defensive situation of the former in the struggle for markets. In the opinion of the author this competition must ultimately affect agriculture in all parts of the world, even though in many countries that are directly concerned, its existence is scarcely yet recognised.

Personal Notes

Dr. I. M. Mackerras, Principal Research Officer, Division of Economic Entomology, C.S.I.R., left Australia a few months ago with the A.I.F. as a pathologist (with the rank of Major) in the Army Medical Corps.

Mr. T. McCarthy and Mr. S. L. Allman have been appointed Chief Entomologist and Senior Entomologist, respectively, in the N.S.W. Dept. of Agriculture.

Dr. N. S. Noble has been appointed lecturer for a new course of studies in horticultural entomology at the Sydney Technical College.

Mr. C. E. Ahrens retired for health reasons from the principalship of Navuso Agricultural College, Fiji, and is now again with the N.S.W. Dept. of Agriculture.

Dr. L. C. Snook, who went abroad over three years ago under a Hackett Studentship, returned to Perth recently. His Doctorate was awarded for work at the Rowett Institute on pregnancy toxæmia of ewes.

Mr. R. S. Mitchell left Queensland in December to take up his appointment as Soil Research Officer in the N.S.W. Soil Conservation Service.

Institute members who recently returned from abroad include Professor S. M. Wadham (Vic.), Dr. H. C. Trumble (S.A.), Mr. A. G. Strickland (S.A.), Mr. J. S. Hosking (S.A.) and Mr. W. T. Atkinson (N.S.W.).

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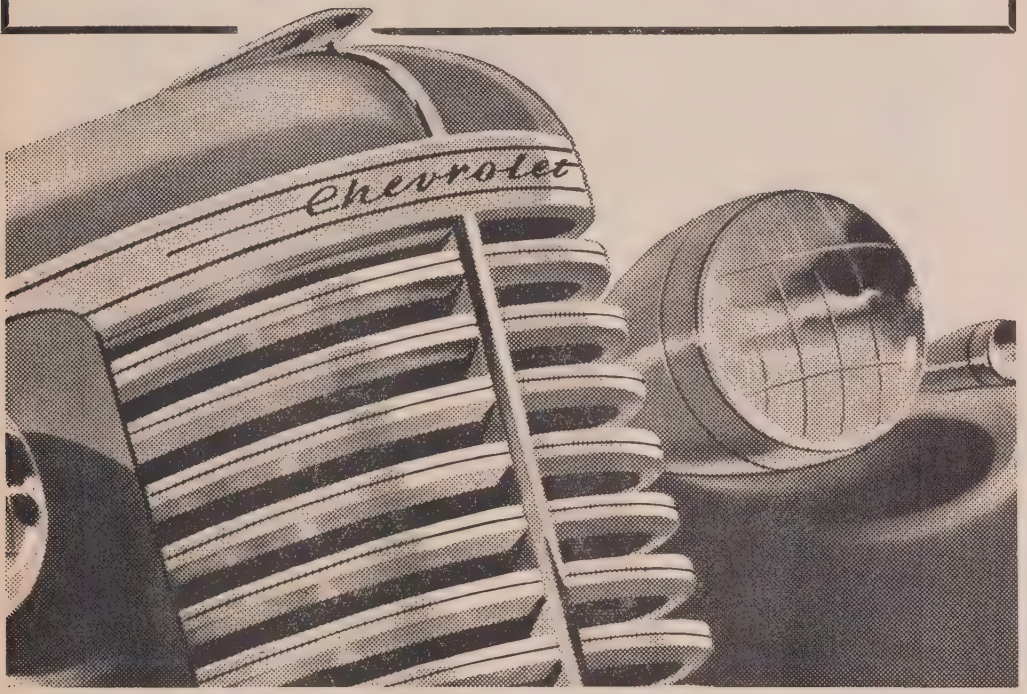

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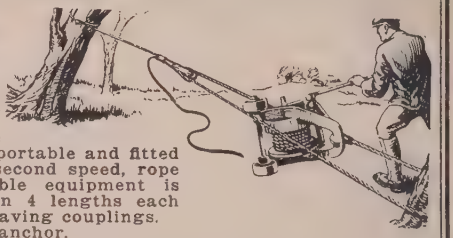

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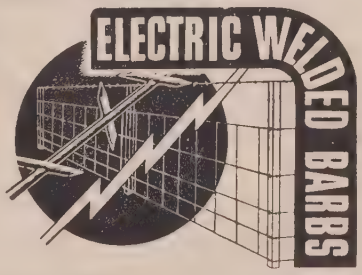

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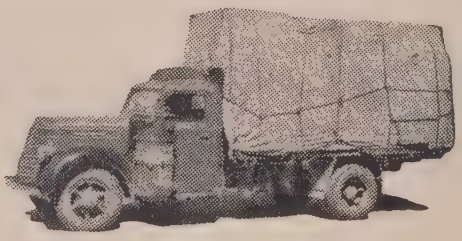

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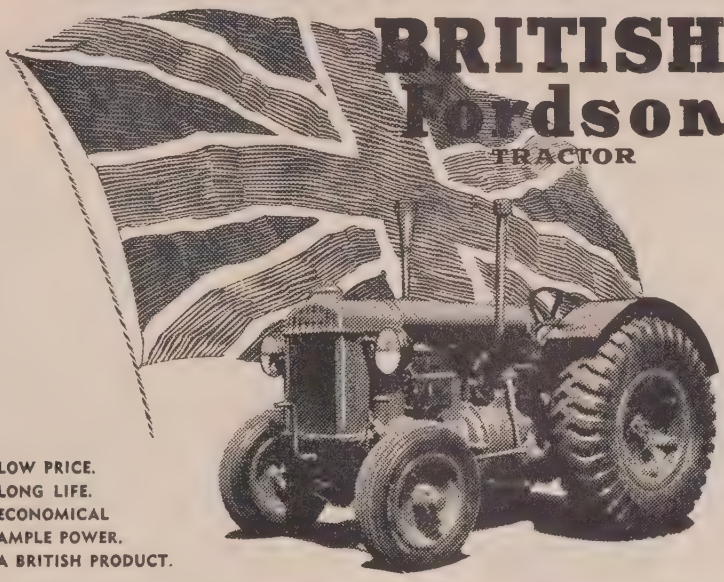

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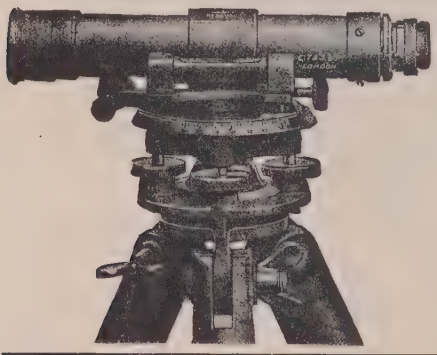

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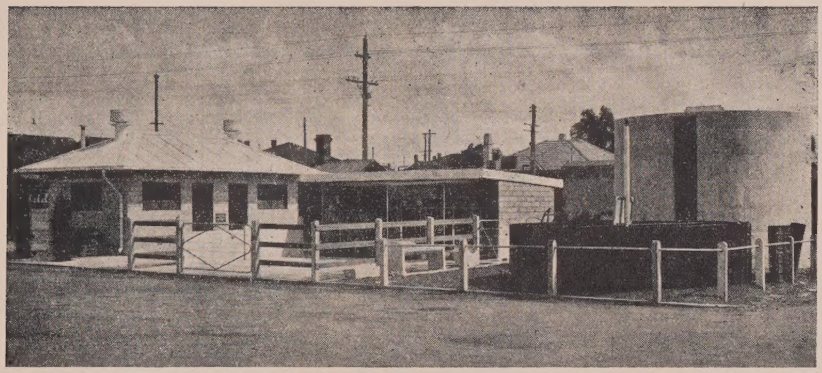

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